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ART. LI.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXI.—*The Early Stages of the American Lobster* (HOMARUS AMERICANUS Edwards); by S. I. SMITH.

THE majority of the published observations on the development of the higher crustacea have been confined to the changes taking place in the embryo within the egg, or immediately after leaving it. Of the later stages, which connect the newly hatched young with the adult, little is known. So far as the published accounts are known to me, this is the case in the history of the common lobster of Europe. On the development of the lobster of our own coast nothing has been published. The investigation, of which this article is a short notice, was undertaken to supply this deficiency in the history of the later development of the lobster, and is one of the results obtained through the facilities for collecting and studying our marine animals, offered last summer by the U. S. Commissioner of the Fisheries, Professor Baird.

The specimens were all obtained in Vineyard Sound, or the adjacent waters, during July, and were mostly taken at the surface in the day-time, either with the towing or hand net. They present three quite different stages in the true larval condition, besides a later stage approaching closely the adult. The exact age of the larvæ of the first stage was not ascertained, but was probably only a few days, and they had, most likely, moulted not more than once, perhaps not at all. Between the third stage, here described, and the last, there is probably an intermediate form wanting. The descriptions and figures have

all been drawn from specimens preserved in alcohol, as there was no opportunity for studying them while alive.

First Stage.—The larvæ of the first stage observed were frequently taken at the surface, and were obtained from the well of a lobster smack, where they were swimming in great abundance near the surface of the water. In this stage (pl. IX, figs. *A*, *B*, *C*, *D*) they are free-swimming Schizopods, about a third of an inch (7·8 to 8·0^{mm}) in length, without abdominal appendages, and with six pairs of pediform cephalothoracic appendages, each with the exopodus* developed into a powerful swimming organ. The general appearance is represented in the figures. The eyes are bright blue: the anterior portion and the lower margin of the carapax and the bases of the legs are speckled with orange; the lower margin, the whole of the penultimate, and the basal portion of the ultimate segment of the abdomen, are brilliant reddish orange. They are very active, swimming about very much like the species of *Mysis* and *Thysanopoda*.

The antennulæ (fig. *C*) are short and sack-like, with a single articulation at the base and three setæ at the tip. The antennæ have large well-developed scales, furnished along the inner margin with long plumose hairs, but the flagellum is shorter than the scale, not divided into segments, and with three plumose setæ at tip. The mandibles are unlike on the two sides; the inferior edges are armed with acute teeth, except at the posterior angle, where there is a small molar area; the palpi are very small and the three segments just indicated. The exognathus in both pairs of maxillæ is composed of only one article, and is furnished with several setæ at tip. In the first maxillipeds, the exognathus is an unarticulated process, furnished with short plumose hairs on the outer side. The second maxillipeds have the principal branch cylindrical, not flattened and appressed to the inner mouth organs as in the adult; the exognathus is short and as yet scarcely flabelliform; and the epignathus is a simple process, with not even the rudiment of a branchia. The external maxillipeds are pediform, the endognathus as long as and much resembling the endopodi of the posterior legs, while the exognathus is like the exopodi of all the legs, being half as long as the endognathus, and the terminal portion furnished along the edges with long plumose hairs. The epignathus and the branchiæ are very rudimentary, represented by minute sack-like processes. The anterior thoracic legs, which in the adult develop into the big claws, are exactly alike, and no

* To prevent confusion the terms here used are those proposed by Milne Edwards to designate the different branches of the cephalic and thoracic appendages: *endopodus*, for the main branch of a leg; *exopodus*, for the accessory branch (*a* in fig. *D*); *epipodus*, for the flabelliform appendage (*b*); and *endognathus*, *exognathus*, and *epignathus*, for the corresponding branches of the mouth organs.

longer than the external maxillipeds. The pediform branch is, however, somewhat stouter than in the outer legs, and subcheliform. The legs of the second and third pairs (fig. *D*) are similar to the first but not as stout. The legs of the fourth and fifth pairs are still more slender, and styliform at the extremity as in the adult.

The exopodal branches of all the legs and of the external maxillipeds are quite similar, and differ very little in size. In life, while the animal is poised at rest in the water, they are carried horizontally, as represented in figure *B*, or are curved up over the carapax, sometimes so as almost to cover it. The blood circulates rapidly in these appendages, and they undoubtedly serve, to a certain extent, as respiratory organs, as well as for locomotion. By careful examination, small processes were found representing the normal number of branchiæ to each leg.* These rudimentary branchiæ, however, differ somewhat in different specimens, being very small, and scarcely distinguishable, in what appear to be younger individuals, from the rudimentary epipodi, while in others, apparently older, they are farther developed, being larger, more cellular in structure than the epipodi, and even showing an approach to crenulation in the margins, as in figure *D*.

The abdomen is slender, the second to the fifth segments each armed with a large dorsal spine curved backward, and with the lateral angles produced into long spines, and the sixth segment with two dorsal spines. The proportional size and the outline of the last segment is shown in figure *B;* its posterior margin is armed with a long and stout central spine, and each side with fourteen or fifteen plumose spines or setæ, which are articulated to the margin.

Second Stage.—In the next stage the larvæ have increased somewhat in size, and the abdominal legs of the second to the fifth segments have appeared. The rostrum is much broader, and there are several teeth along the edges. The basal segments of the antennulæ have become defined, and the secondary flagellum has appeared but is not subdivided into segments. The antennæ and mouth organs have undergone but slight changes. The first thoracic legs are proportionately larger and stouter

* The number of branchiæ, or branchial pyramids, in the American lobster is twenty on each side: a single small one upon the second maxilliped, three well-developed ones upon the external maxilliped, three upon the first thoracic leg, four each upon the second, third and fourth, and one upon the fifth. This number is perhaps different in the European species. De Haan (Fauna Japonica, Crustacea, p. 146) gives the number, for the genus *Homarus*, as nineteen on each side, giving only two for the external maxilliped, while Owen (Lectures on the Anatomy of the Invertebrate Animals, 2d ed., p. 322) and Edwards (Hist. nat. des Crust., i, 86) give the whole number on each side as twenty-two, although Edwards in the second volume of the same work, under *Homarus*, p. 333, gives twenty as the number.

than in the first stage, and have become truly cheliform. The succeeding legs have changed little. The epidodi of all the legs and of the external maxillipeds have increased in size, and the branchial processes are distinctly lobed along the edges, and have begun to assume the form of true branchiæ. The segments of the abdomen have the same number of spines but they are relatively somewhat smaller, and the last segment is relatively smaller and broader at base. The appendages of the second to the fifth segments differ considerably in size in different specimens, but are nearly as long as the segments themselves; their terminal lamellæ, however, are represented only by simple sack-like appendages, without sign of segmentation, or clothing of hairs or setæ. The penultimate segment is still without appendages.

Third Stage.—In the third stage (pl. IX, figs. *E*, *F*, *G*) the larvæ are about half an inch (12 to 13^{mm}) in length, and the integument is of a much firmer consistency than in the earlier stages. The antennulæ are still rudimentary, and considerably shorter than the rostrum, although the secondary flagellum has increased in length, and begins to show division into numerous segments. The antennæ retain the most marked feature of the early stages—the large size of the scale—but the flagellum is much longer than the scale, and begins to show division into segments. The mandibles, maxillæ, and first and second maxillipeds have changed very little, although in the second maxillipeds, the extremity of the exognathus begins to assume a flagelliform character, and the branchia is represented by a small process upon the side of the epignathus. The maxillipeds have begun to lose their pediform character. The anterior legs have increased enormously in size, and those of the second and third pairs have become truly chelate, while the swimming exopodal branches of all the legs, as well as of the external maxillipeds, are relatively much smaller and more unimportant. The epipodi (fig. *D*) are furnished with hairs along the edges, and begin to assume the characters of these appendages in the adult. The branchiæ (fig. *D*) have developed rapidly, and have a single series of well-marked lobes along each side. The abdomen still has the spines characteristic of the earlier stages, though all of them are much reduced in size. The appendages of the second to the fifth segments have become conspicuous, their lamellæ have more than doubled in length, and the margins of the terminal half are furnished with very short ciliated setæ. The appendages of the penultimate segment (fig. *F*) are well developed, although quite different from those in the adult. The outer lamella wants wholly the transverse articulation near its extremity, and both are margined, except the outer edge of the outer lamella, with long plumose

hairs. The last segment is relatively smaller and more quadrangular in outline, and the spines of the posterior margin are much smaller.

Fourth Stage.—In the next stage observed, the animal, about three fifths of an inch (14 to 17^{mm}) long, has lost all its schizopodal characters, and has assumed the more important features of the adult lobster. It still retains, however, the free-swimming habit of the true larval forms, and was frequently taken at the surface, both in the towing and hand net. Although resembling the adult in many features, it differs so much that, were it an adult form, it would undoubtedly be regarded as a distinct genus. The rostrum is bifid at tip, and armed with three or four teeth on each side toward the base, and in some specimens with a minute additional spine, on one or both sides, close to the tip. The flagella of the antennulæ extend scarcely beyond the tip of the rostrum. The antennal scale is very much reduced in size, but is still conspicuous and furnished with long plumose hairs along the inner margin, while the flagellum is as long as the carapax. The palpi of the mandibles have assumed the adult character, but the mandibles themselves have not acquired the massive molar character which they have in the older animal. The other mouth organs have nearly the adult form. The anterior legs, although quite large, are still slender and just alike on the two sides, while all the thoracic legs retain a distinct process in place of the swimming exopodi of the larva.

The lateral angles of the second to the fifth abdominal segments are prolonged downward into long spiniform teeth, the appendages of these segments are proportionately much longer than in the adult, and the margins of their terminal lamellæ are furnished with very long plumose hairs. The lamellæ of the appendages of the penultimate segment are oval, and margined with long plumose hairs. The terminal segment is nearly quadrangular, as wide at the extremity as at the base, the posterior margin arcuate, but not extending beyond the prominent lateral angles, and furnished with hairs like those on the margins of the lamellæ of the appendages of the penultimate segment.

In this last stage, the young lobsters swim very rapidly by means of the abdominal legs, and dart backward, when disturbed, with the caudal appendages, frequently jumping out of the water in this way like shrimp, which their movements in the water much resemble. They appear to be truly surface animals as in the earlier stages.

From the dates at which the different forms were taken, it is probable that they pass through all the stages here described in the course of a single season. How late the young, after reaching the lobster-like form, retain their free-swimming habit was not ascertained.

EXPLANATION OF PLATE IX.

Figure *A*. Lateral view of the larval young in the first stage observed, enlarged 10 diameters.

" *B*. The same in a dorsal view, the abdomen held horizontally.

" *C*. Antennula, enlarged 20 diameters.

" *D*. One of the thoracic legs of the second pair, enlarged 20 diameters; *a*, exopodus; *b*, epipodus; *c*. branchiæ.

" *E*. Lateral view of the larval young in the third stage, enlarged 8 diameters.

" *F*. Terminal portion of the abdomen seen from above, enlarged 15 diameters; *a*, one of the small spines of the posterior margin of the terminal segment, enlarged 75 diameters.

" *G*. Basal portion of one of the legs of the second pair, showing the epipodus and branchiæ, enlarged 20 diameters.

ART. LII.—*Remarks on the Nomenclature of Achromatic Objectives for the Compound Microscope;* by Dr. J. J. WOODWARD, U. S. Army.

FOR some years past, while most of the Continental opticians have continued to give arbitrary designations to their achromatic object glasses, such as No. 1, No. 2, &c., or System A, System B, &c., the English and American manufacturers, affecting a higher degree of accuracy, have undertaken to name the objectives they construct by their real or supposed agreement in magnifying power, with single lenses of specified focal lengths. We hear accordingly of inch, half-inch and quarter-inch objectives, &c., by which we are expected to understand combinations agreeing in magnifying power with single convex lenses of the focal lengths named.

At first sight nothing could appear simpler or more exact than such a nomenclature; nevertheless recent articles in the journals would seem to indicate that the general plan is capable of considerable modification in its practical application, and that grave misunderstandings have hence arisen.

Under these circumstances, it appears desirable to give some account of the principles involved, and of the practical difficulties to be considered in their application, particularly as the microscopical text-books contain little or no information on the subject. In fact, the only scientific discussion of the matter with which I am acquainted is the paper of Mr. Charles R. Cross, "On the focal length of microscopic objectives." (Journal of the Franklin Institute, June, 1870, p. 401). This paper gives a reasonable formula for the approximate computation of equivalent focal lengths, and furnishes some other valuable information, but does not discuss all the points at issue. I shall have occasion to refer more than once to this excellent paper, which the reader would do well to examine in connection with the following remarks.

We learn from the elementary treatises on optics that when an object is placed in front of a single convex lens at a distance somewhat greater than its focus for parallel rays, a real image is formed on the other side of the lens, which may be received on a screen. This image will be larger, and formed at a point more distant from the lens, the nearer the object approaches to the focus for parallel rays; and two equations are given which express the relationship of the distances to each other and to the magnifying power, viz:

$\frac{1}{f}=\frac{1}{p}+\frac{1}{p'}$, and $\frac{p'}{p}=m$, in which f is the length of the focus for parallel rays, p the distance of the lens from the object, p' its distance from the image, and m the true magnifying power, that is, the size of the image divided by the size of the object; p and p' are termed the conjugate foci and are variable quantities; f is termed the principle focus, and has an unchangeable value for each single lens.

If now we combine the above equations, representing $p + p'$ or the sum of the conjugate foci by l, we may deduce the formula $f=\frac{m\,l}{(m+1)^2}$ which represents in the case of any single convex lens the relationship existing between the length of the principal focus, the magnifying power, and the distance from the object to the screen. This formula, which I think rather more convenient than that of Mr. Cross, differs from it only in using m = the magnifying power, instead of n = the reciprocal of the magnifying power; it may be deduced from his by substituting for n its value $\frac{1}{m}$ and reducing, or it may be derived directly from the primitive equations. In either shape the formula yields the same numerical results, and if for any single convex lens m and l are given, the accuracy of the value of f resulting, will be limited only by the degree of precision with which m and l have been measured.

If now there were any such actual equivalence between achromatic objectives and single lenses as the nomenclature assumes, it would only be necessary to set up the objective to be rated, in such a manner that the image of a micrometer should be focussed upon a white screen, using of course no eye-piece, to measure the distance from the micrometer to the screen, to determine the magnifying power by measuring the image of the micrometer, and substituting these values of l and m in the working formula to calculate the value of f. Unfortunately, however, if with any compound objective we repeat this operation several times, merely varying the distances, we obtain as many different values for f as there are distances used, instead of obtaining but one value for all distances as we do with a single lens.

Mr. Cross (loc. cit. p. 409) has already pointed out this circumstance which results from the fact that the modern achromatic objective has considerable thickness, from its anterior to its posterior surfaces, and that it has properly speaking no true optical center. He gives two examples, in one of which a change of 5·24 inches in distance corresponded to a change of ·0067 inch in calculated focal length; in the other a change of 6·10 inches in distance corresponded to a change of ·0029 inch in calculated focal length the objectives used in the experiment being uncorrected $\frac{1}{4}$ths, so called. If, however, Mr. Cross had used for this purpose lower powers, or had made greater variations in the distances employed, he would have found much greater discrepancies. For example, by measuring the magnifying power first at 25 and then at 50 inches, and deducing the value of f by the formula of Mr. Cross, I obtained in two cases the following equivalent focal lengths. For a so-called $1\frac{1}{2}$ inch, at 50 inches distance, 1·2187 inches; at 25 inches distance, 1·2468 inches; difference ·0271 inch. For a so-called $\frac{1}{2}$th, at 50 inches distance, ·1982 inch; at 25 inches distance, ·1893 inch; difference ·0089 inch.

Moreover, since the achromatic objectives of different makers are constructed on different series of curves, and the component lenses placed at different distances apart, it will be found that if two achromatic objectives magnify the same at any given distance, they will no longer do so if the distance is materially changed.

Hence I am compelled to agree fully with the observations of Mr. Cross (loc. cit. p. 401), that the nominal focal length assigned to an achromatic objective can only serve in any case as "a general appellation serving to group together objectives of *approximately* the same magnifying power," and must conclude, therefore, that the English and American nomenclature possesses no real claim to strict scientific accuracy, and especially that the comparison made by some with the case of the celestial telescope is not valid.

But besides the inevitable inaccuracy resulting from this source, there are in the case of the higher powers of modern makers two other sources of much more considerable error. The first of these involves the case of all those objectives which are provided with a screw collar to correct for thickness of cover; the second involves the case of objectives with two fronts, one for wet and the other for dry, or those with but one front which can be used wet or dry by merely changing the correction given by the screw collar.

The correction for thickness of cover is made, as is well known, by changing the distance between the front combination of the triplet and the posterior two combinations. As a

consequence, the magnifying power of the objective at any given distance, or with any given eye-piece, is least when the objective is corrected for uncovered, and greatest when it is corrected for the thickest cover through which it will work. The ratio of this change is very different in different objectives. I select a few from my note book in illustration, purposely omitting to name the makers.

	Magnifying power at uncovered.	Magnifying power at covered.
No. 1,	200	225
No. 2,	250	275
No. 3,	300	333
No. 4,	350	500
No. 5,	570	630
No. 6,	900	1100
No. 7,	975	1180
No. 8,	890	1250

These values were obtained by throwing the image of a micrometer on a card board screen, using the objective without an eye-piece, and the distance from micrometer to screen in each case remained the same, the screw collar and the focal adjustment of the objective being modified. Of course, for all intermediate positions of the screw collar intermediate values result. The distance used was 48 inches in some of the cases, 50 in the others. With shorter distances, the amount of the difference is diminished, but its ratio to the magnifying power at uncovered is not materially changed, as any one can convince himself by comparing a stage micrometer, as seen by any corrected objective, with an eye-piece micrometer, first at uncovered and then with the full correction for cover.

Now it is evident that even if, by the formula of Mr. Cross, or otherwise, we could obtain accurate equivalent focal lengths for any one position of the cover correction, the result would not be true for any other position of the cover correction.

We are told by a recent writer that the practice of the opticians is to name the combination at its performance uncovered, that is, at precisely the adjustment least used. If, however, scientific accuracy in the matter is desirable for any purpose whatever, it is evident from the above that at least the maximum and minimum should be furnished by the maker.

It is also evident that the considerations here offered, aside from their bearing on the nomenclature of objectives, have a high practical value to all those who attempt to make micrometric measurements with modern high power objectives; for the practice recommended in the text-books, and too generally pursued, is to give values to an eye-piece micrometer by comparing it with a stage micrometer at a fixed position of the draw tube, and to use these values in subsequent measurements.

Now as these values vary considerably with the cover correction, it is to be feared that the majority of the measurements, made with high powers during the last twenty years are sadly inaccurate.

The difficulties in the way of a nomenclature based upon equivalent focal lengths have been still further increased since the introduction of immersion objectives. The compound objective is usually furnished with two fronts, one for wet and one for dry use. Of these the wet usually gives the greatest magnifying power at any given distance. I have also measured an objective which, when corrected for the thickest cover through which it will work dry, is just corrected for uncovered wet, and by approximating the posterior pair of combinations still nearer to the anterior, corrects for cover wet, thus increasing the magnifying power when the objective is in use wet precisely as if two fronts were used.

The difference in magnifying power resulting from the modifications given to make the objective perform wet is quite considerable, as may be seen by the following extracts from my note book.

	Magnifying power.			
	Dry.		Wet.	
	Uncovered.	Covered.	Uncovered.	Covered.
No. 1,	225	250	250	275
No. 2,	425	490	450	500
No. 3,	700	900	900	1000
No. 4,	770	910	900	1100
No. 5,	790	930	975	1180

Of these objectives No. 1 had but one front, the correction for wet being made by the cover correction; the others had two separate fronts, one for wet, the other for dry.

Now it is just in connection with these complex objectives, with double fronts or other devices to correct for wet and dry, that the greatest diversity of nomenclature exists. In one quarter it is claimed that the system should have two names, one based on its magnifying power at uncovered wet, the other on its magnifying power at uncovered dry; in other quarters the practice has been to give the system but a single name derived from the magnifying power at uncovered dry alone. It is evident, however, that neither of these plans has any pretension to scientific accuracy, and that if the makers will not give at least the maximum and minimum for both dry and wet, the purchaser must learn to measure for himself.

A similar remark applies to the angle of aperture as stated by the makers, for each objective sold. As a rule they give the greatest angle attainable by the combination, which is generally,—not always,—the angle at the correction for thickest

cover, their usual practice in this case being the reverse of their usual practice with regard to magnifying power. Now I have seen objectives with an angle of 170° and upward at full cover correction, which did not exceed 140° at uncovered. It is evident, therefore, that the maker should furnish with each glass both the maximum and minimum angle, or the microscopist must measure for himself.

After a full consideration of all the circumstances, I am disposed to think that the best interests of both makers and purchasers would be consulted if the present nomenclature were abandoned altogether, and objectives named instead by their precise magnifying power without eye-piece at some selected distance. It would be well if all the makers could be brought to agree on some fixed distance; but until we obtain this happy uniformity, which perhaps is not to be anticipated, it is only necessary for each maker to state the distance he selects. By this plan objectives without correction for cover would be named by one number, objectives with correction by two, and those with two or more fronts or backs by two or more pairs of numbers.

Thus we should have objectives without cover corrections named precisely 2, 3, 4, 5, 6, 7, 8, 9, and so on up to 100 or more, the number indicating the exact magnifying power, say at twelve and a half inches from micrometer to screen. Objectives with cover corrections would be named 30 to 40, 35 to 46, 75 to 89, 125 to 140, &c., the numbers representing the minimum and maximum magnifying powers at the selected distance. Objectives with wet and dry fronts would require a separate name for each; thus 78 to 95 dry, 98 to 130 wet, &c.

By this plan the real magnifying power of the glass and its limits of variation would be accurately stated, whereas at present even those makers who are most careful about their nomenclature do not hesitate to call a glass an $\frac{1}{5}$th provided its power at uncovered approximates that of a single lens of $\frac{1}{5}$th of an inch focus more nearly than it does a $\frac{1}{6}$th or a $\frac{1}{4}$th. Hence glasses which differ materially in magnifying power at uncovered, receive the same name, and the changes in power produced by the cover correction, are invariably ignored.

If the plan I here recommend be adopted, the precise distance from micrometer to screen which may be chosen does not appear to me to be of very great importance. Many persons would I suppose prefer 10 inches to $12\frac{1}{2}$. I have selected the latter number because many of our larger stands have tubes too long to permit the convenient measurement of low powers with eye-piece and stage micrometers, in the manner I shall presently describe, if the distance be taken at 10 inches, whereas on most stands, with the help of the draw tube, $12\frac{1}{2}$ inches can be used

conveniently with all powers from the three inch upward. I do not, however, insist on any particular distance, but only that the distance selected shall be stated in each case until some uniform plan shall be generally agreed upon.

In this connection I may add that the actual plan of the Continental opticians is also unsatisfactory. In the matter of angle of aperture, when they give it at all, they also, as a rule, give only the maximum. In the matter of magnifying power, when they give any information, they attempt, as a rule, to give the magnifying power of the objective with each eye-piece as actually looked through when in use. But as the magnifying power of the combination under these circumstances involves the distance of distinct vision for each observer, it is evident that the figures thus furnished cannot have any practical value.

Pending the adoption of some such system as I have suggested above, it will be necessary for the microscopist to measure for himself the magnifying power of the objectives he uses, whenever he desires to be possessed of the real information concealed behind all the several systems of nomenclature at present in use. Mr. Cross in his paper gives two modes of doing this. I myself have been in the habit of using a dark room, and throwing the image of the micrometer on a white screen, by the direct rays of the sun. Very nearly equal accuracy may be attained, however, by any microscopist who possesses an ordinary glass eye-piece micrometer and a stage micrometer. The glass eye-piece micrometer, it will be recollected, is slipped through the eye-piece in such a manner as to be just in the focus of its eye-glass, that is, in the plane which is occupied by the image formed by the objective when it is seen most distinctly. If now the field glass of such an eye-piece be removed, and the stage micrometer carefully brought into focus, a comparison of the divisions of the eye-piece and stage micrometers will give the magnifying power of the objective alone at the distance actually existing between the two micrometers. Thus, for example, if the stage micrometer is in $\frac{1}{100}$ths and the eye-piece micrometer in $\frac{1}{20}$ths of an inch, five times the number of eye-piece divisions corresponding to one division of the stage micrometer will be the magnifying power of the objective at the cover correction employed, for the distance selected. We may then apply the following simple rule, derived from the formula of Mr. Cross.

Multiply the distance between the two micrometers in inches and decimals, by the magnifying power, and divide by the square of the magnifying power plus one; the result will be the equivalent focal length (for the given conditions) in decimals of an inch.

It will, moreover, be found in practice that for powers equivalent to those of a $\frac{1}{4}$th or shorter focal lengths a still simpler rule may be adopted, and that the distance between the two micrometers, divided by the magnifying power, will give very nearly the same results as are obtained by the more complex rule, but this of course is not true for lower powers.

It must, however, be constantly borne in mind that the results obtained in any case are true only for the cover correction and distance used.

For the convenience of those who may undertake such comparisons, I append a table in which the real magnifying powers of single convex lenses are given for three different distances. In the treatises on optics the magnifying powers of single lenses are sometimes stated at some given distance from the lens to the screen, but I know of no table which shows their powers at given distances between image and object.

This table is calculated by substituting the numerical values of f and l in the equation $f = \frac{ml}{(m+1)^2}$, when m = the magnifying power remains as the only unknown quantity and is easily computed. I have carried out the values of m to two decimal places only; but in practice the nearest whole number will be found sufficiently accurate.

Table of the magnifying powers of single convex lenses.

Focal length for parallel rays.	Magnifying power at 12½, 25, and 50 inches distance from micrometer to screen.		
	12 1-2 inches.	25 inches.	50 inches.
3 inches,	1·50	6·17	14·59
2 "	4·00	10·40	22·95
1½ "	6·17	14·59	31·30
1 inch,	10·40	22·95	47·99
⅔rds of an inch,	16·69	35·47	72·98
$\frac{4}{10}$ths "	29·21	60·48	122·99
¼th "	47·99	97·98	197·99
⅕th "	60·48	122·99	247·99
⅙th "	72·98	147·99	297·99
⅛th "	97·98	197·99	397·99
$\frac{1}{10}$th "	122·99	247·99	497·99
$\frac{1}{12}$th "	147·99	297·99	597·99
$\frac{1}{15}$th "	185·49	372·99	747·99
$\frac{1}{16}$th "	197·99	397·99	797·99
$\frac{1}{18}$th "	222·99	447·99	897·99
$\frac{1}{20}$th "	247·99	497·99	997·99
$\frac{1}{25}$th "	310·49	622·99	1247·99
$\frac{1}{30}$th "	622·99	1247·99	2497·99

Note.—Since writing the foregoing article, I have read with pleasure a paper on the same subject by Dr. R. H. Ward

("Remarks on uniformity of nomenclature in regard to microscopical objectives and oculars," American Naturalist, March, 1872, p. 136). This paper contains much valuable matter, and should be read by all who are interested in this subject. I learn from it for the first time that the method of determining the magnifying power of objectives by removing the field glass of the eye-piece and using eye-piece and stage micrometer as described above, has already been used by Dr. J. J. Higgins of New York (American Naturalist, Dec., 1870, p. 628), to whom I hasten to give the credit due.

I am very glad to find Dr. Ward indicates the feasibility of the substitution of magnifying powers at a fixed distance as names for objectives instead of alleged equivalent focal lengths. I must, however, differ from him when he recommends that the distance should be measured from some part of the objective to the screen, instead of from the micrometer to the screen; for however desirable this may be made to appear, it is not feasible. Nor can I agree with him in regarding ten inches distance as having anything special to recommend it. To the question he asks at the conclusion of his paper, "at what point of the screw collar adjustment shall the objective be placed for rating its angular aperture and amplifying power?" I reply without hesitation that for each purpose accuracy demands that the maximum should be given as well as the minimum; that the maker should state not merely one limit, but both.

Dr. Ward's paper also contains some interesting suggestions on the subject of the nomenclature of eye-pieces, a matter which will, however, I think, particularly in the case of the ordinary eye-piece, require further discussion. I agree fully with Doctor Ward that eye-pieces should be named by their magnifying power: but the question at once arises, how shall this be accurately measured? To this subject I may recur at some future time.

ART. LIII. — *On a new form of Lantern-Galvanometer;* by ALFRED M. MAYER, Ph.D., Professor of Physics in the Stevens Institute of Technology, Hoboken, N. J.

ON the 21st of December, 1871, I delivered a lecture on Magnetism before the American Institute, at the Academy of Music, in the city of New York. It was necessary for the experimental discussion I then made of the earth's magnetism to use a galvanometer, so constructed that the least deflection of its needle would be visible to a very large audience; at the same time the astatic condition of this needle had to be so

controlled that it could readily be altered during the progress of the lecture; while finally, the arrangement of the damping magnets had to be such as allowed me instantly to bring the needle into the magnetic meridian when disturbed therefrom, whenever I set in action the huge electro-magnet used on that occasion. Indeed, one of the principal uses to which this galvanometer was applied, in the lecture, was the exploration of the magnetic condition of the space surrounding this electro-magnet. This I accomplished by rotating, around the line of "the dip," as an axis, wire coils at various distances and positions, and leading the induced magneto-electric currents through the galvanometer.

The lantern-galvanometer, which I will now proceed to describe, I devised on the 13th of last November, and as subsequent work with it has convinced me of its value in the lecture-room, I have decided to give it this formal publication.

Referring to the figure; M is a plane mirror inclined 45° to the vertical. In front of this are the back condensing lenses of an oxyhydrogen lantern; while the front lens of the condenser is placed in a horizontal position at *c*, *above* the mirror. The back condensing lenses are of such curvatures that when the calcium light is placed about two inches from the one nearest it, a nearly parallel beam issues from them to fall upon M, thence to be reflected to the upper condensing lens at *c*,* on which rests a disc of glass on whose border is photographed a divided circle. In the center of this disc is a short needle point on which freely rotates a magnetic needle. Above the needle is the projecting lens L, the pencils from which are reflected in any desired direction by means of the plane mirror R, which revolves on a horizontal axis and has also a motion in azimuth around the axis of the lens.†

The horizontal condensing lens is five inches in diameter, and the magnetic needle is four inches long. With this arrangement I have obtained sharp and bright images of the graduated circle 16 feet in diameter.

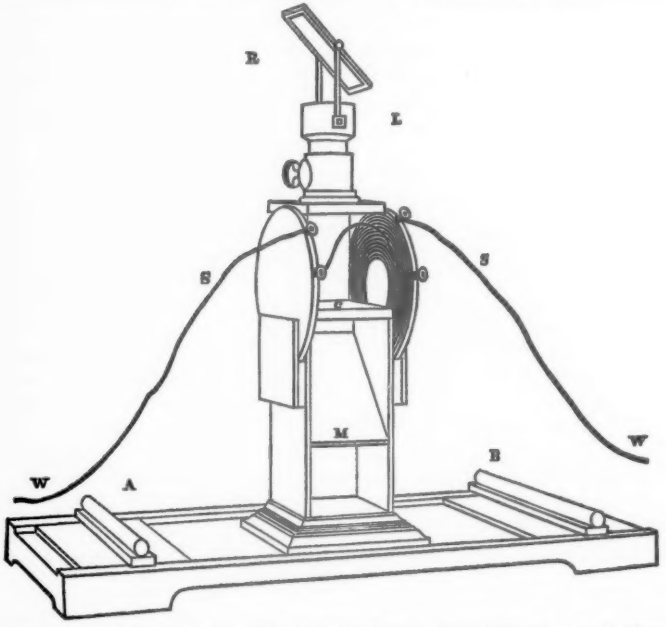
* This arrangement of lenses, which is due to President Morton, gives a bright and uniformly illuminated field free from coloration.

In the *Quarterly Journal of Science*, Oct. 1871. is a report of Prof. Morton's account of this invention ["the vertical lantern"], delivered before the American Institute, as follows: "The original idea and general plan of the instrument shown, was, as the speaker stated, due to Professor J. P. Cooke, of Cambridge; his own work in connection with it being confined to the devising of a convenient mechanical arrangement of parts, the improvement of the combination of condensing lenses with the reflecting lenses [mirror?] so as to secure a white and evenly illuminated field on the screen, and the discovery that an ordinary silvered mirror would serve for the final reflection as efficiently as a metal speculum or glass silvered by Foucault's plan, which are so difficult to obtain and keep in order."

† In a college course of lectures it is sometimes convenient to reflect the image of circle and needle down on a white covered table below the class. The galvanometer can then be placed on the lecture table.

To deflect this needle by means of an electric current I place as close to the condensing lens as possible the two vertical wire spirals S, S, formed of $\frac{1}{16}$ inch copper wire of *square* section, so as to bring the convolutions as close together as possible. The turns of the spirals are separated with very thin vulcanite ribbon, coated with paraffine, and are wrapped on the faces of vulcanite discs. The spirals have an internal diameter of four inches and an external diameter of ten inches, and each contains 49 feet of wire in 26 turns. The four terminals of the spirals are connecting screws, two of which serve to connect the spirals so that a current will circulate in the same direction in both. The spirals are so placed that a line joining their centers will pass through the center of the magnetic needle.

The vertical-lantern rests on a base three feet and a half long, with guides on its sides, between which slide boards carrying two bar-magnets, A and B, 15 inches long and one inch in diameter, as shown in the figure. These magnets can-



not only approach to and recede from the lantern, and thus alter their distances from the galvanometer-needle, but they can also rotate around their centers on vertical axes. The like poles of the magnets and of the needle point in the same direction; and by sliding the magnets to or from the lantern-needle we

render the latter more or less astatic. Also, in case the needle should not hold to the meridian as you approach the magnets, it can be made to do so by rotating one or both of them in the horizontal plane; and thus, also, can be neutralized any exterior disturbance which may tend to deflect the needle from the magnetic meridian.

The needle may be also rendered astatic, in the usual way, by suspending it by a silk fiber and attaching to this needle a wire which passes through a hole in the condenser and in the inclined mirror and carries beneath the latter another needle with poles reversed.

In working with thermal currents we use a smaller needle and condenser which allows the spirals to approach nearer; but for thermal currents it is better to wind close around the needle a flat coil of only one wire in breadth, and to use a suspended astatic system of which the *lower* needle is the stronger and is under the control of the damping magnets.* The breadth of the coil used in this last device need not exceed $\frac{1}{2}\frac{1}{5}$th of an inch, and its image on the screen can answer for a rough zero point.

I will now give a few experiments in which this galvanometer has been used; and they will serve to show its usefulness.

Experiment 1. A coil of $2\frac{1}{2}$ feet in diameter, containing 40 turns of 300 feet of $\frac{1}{1}\frac{1}{6}$th inch wire, was placed, with its plane, at right angles to "the dip." Its terminals were connected with the galvanometer whose needle was rendered astatic by means of the the damping magnets. I now quickly rotated the coil 180° around an axis at right angles to the direction of dipping-needle. The galvanometer needle was deflected about 12° by the magneto-electric current induced by the earth's magnetism.

Exp. 2. I placed the coil, used in Exp. 1, on a wooden wheel provided with a commutator and rotated it around an axis at right angles to the dip. The galvanometer-needle went steadily up to a deflection of 85° and was held there as long as the coil revolved.

Exp. 3. The two cores of the large electro-magnet of the Stevens Institute of Technology were placed end to end, thus forming one iron bar, seven feet long and six inches in diameter. This was surrounded by its eight bobbins containing in all 2000 feet of $\frac{1}{2}$ inch copper wire; and through them was sent the electricity developed by the most advantageous combination of 60 plates of zinc and carbon, 10×8 inches.

* The upper needle of this astatic combination swings in the interior of the coil which incloses both the needle and the condenser *c;* the lower needle swings under the inclined mirror M, and is attached to the upper needle by means of a stiff wire which passes through holes in the condenser and to the inclined mirror. In another combination I have placed this lower needle *above* the coil, and have "damped" it by means of a magnet placed above the reflector R.

A coil of 20 inches in diameter formed of one turn of $\frac{1}{20}$ inch wire was rotated 180° around a vertical axis 3½ feet from the end of the magnet. The needle was deflected 3°.

Exp. 4. A coil of 20 inches in diameter having 5 turns of $\frac{1}{20}$ inch wire was rotated 180° around a vertical axis, at a distance of 3½ feet from end of magnet. Deflection of needle was 30°.

Exp. 5. Same as Exp. 4, only coil had 10 turns of wire instead of 5. Galvanometer needle deflected 50° to 60°.

Exp. 6. A coil of 20 inches in diameter formed of 10 turns, $\frac{1}{20}$ inch wire was revolved 180° around a vertical axis 6½ feet from end of magnet. Deflection of 22°.

Exp. 7. The coil used in Exp. 6, was placed three feet eight inches above center of axis of the magnet and revolved 180° around a vertical axis; the needle was deflected 80°.

Exp. 8. A coil of 2½ feet in diameter, formed of 40 turns of 300 feet of $\frac{1}{10}$ inch wire, was placed 28 feet distant from the center of the magnet, and with its plane coinciding with the plane of the magnet's equator. On rotating it around a vertical axis the needle was deflected 20°.

The following experiments will show the excellent proportions (arrived at by a long series of experiments) of the coil used in Exps. 1, 2 and 8, for the evolution and study of the electric currents induced by the earth's magnetism.

Exp. 9. The coil used in Exps. 1, 2 and 8 was laid on a table and its terminals connected with a galvanometer, which is used in connection with Nobili's thermo-electric pile. The needles of this instrument made one oscillation in nine seconds. I lifted the east side of the coil only six inches; the needle was deflected 10°. Lifting the same side nine inches, the needles went to 22°. I now placed the coil in a north and south vertical plane and suddenly tilting its top six inches to the east or to the west the needles went to 60°. Tilting the coil nine inches sent the needles with a blow against the stop at 90°.

The advantages of the new galvanometer may be summed up in a few words. It gives on the screen a bright clear image of only the graduated circle and of the needle. It can readily be rendered more or less astatic to adapt it to the character of the electric currents worked with. The direction of its needle is completely under the control of the damping magnets; and, finally, it is of simple construction and can be rapidly adjusted to the requirements of any special experiment.

ART. LIV.—*Descriptions of some new species of Primordial Fossils;* by S. W. FORD.

Hyolithes impar, n. sp.

THE shells of this species are plump, elongate bodies, tapering to an acute point. The largest specimen obtained would, if perfect, be one and three-fourths inches in length. The usual length, however, is about one and one-fourth inches. The section is generally broadly and regularly oval, but in some specimens is rather more flattened on the ventral side than in the diagram of the one below given. Some specimens show a tendency to become keeled along the dorsum, but this feature is rare and not well defined in any case. In an imperfect specimen 1·14 inches in length, the rate of tapering on the ventral side is ·10 of an inch in a distance of ·60 of an inch. The width of the tube at the aperture is ·32, and the depth ·26 of an inch. In this specimen the lower lip projects beyond the limit of the dorsum ·14 of an inch. The surface is ornamented with fine engirdling lines, which upon the ventral side curve gently forward, thence more sharply backward upon the sides until they reach a point at about the middle of the depth, where they are again deflected, and flow across the dorsum in uninterrupted, slightly forward-bending curves. There are also prominent sub-imbricating lines of growth, which give to some of the specimens an exceedingly rugose aspect.

The operculum is of an oval form, irregularly convex externally, and for the most part concave within. The nucleus is situated at the center, and in perfect specimens is vertical and acute. On either side of the nucleus, in the line of the longer diameter, there exists a conspicuous groove, which gradually widens in passing from the center out to the edge. With the exception of the nucleus, which barely separates them, these grooves divide the operculum externally into two equal parts. These are respectively the dorsal and ventral limbs. The ventral limb is smooth on the outside, or broken only by concentric lines. Its convexity is greatest at the nucleus. The dorsal limb has nearly, sometimes quite, the same degree of convexity, but may be

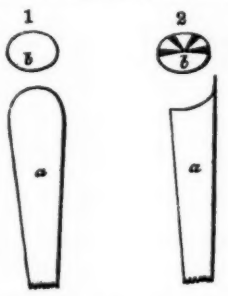


Fig. 1 *a*, outline of a shell of *H. impar*, seen from the most flattened or ventral side; 1 *b* transverse section. 2 *a*, side view to show the form of the aperture and the extension of the lip. 2 *b*, is the interior of an operculum, natural size.

readily distinguished from the ventral by the presence of two obscure ridges radiating from the nucleus to the margin, and enclosing a triangular space along the central portion of the limb. The two limbs are so situated relatively to each other as to give to the base of the operculum a curvature equal to that indicated by the form of the aperture of the shell. In the interior of the operculum there is a little pit directly beneath the nucleus. From this point radiate two strong wedge-shaped ridges corresponding to the exterior grooves. There are also two ridges of similar form running from the same point to the margin of the dorsal limb, lying beneath, and included within, the limits of the triangular space seen on the outside of that limb. All of these ridges are widest at their junction with the margin. They severally terminate in the central pit, and divide the interior into four unequal parts.

The surface of the operculum is covered with fine concentric striæ, from 8 to 10 in the space of ·06 of an inch. Along with these there sometimes occur coarser lines of growth. The interior is both radiately and concentrically striated. The concentric lines are mostly coarser, fewer in number, and far less regularly disposed than those on the outside. The radiating lines are very numerous, and with the concentric lines give to the interior a singularly reticulated appearance under the magnifier. They are barely visible to the naked eye.

This is a well marked species, and offers but little variation of form. It is closely related to *Hyolithes communis* Billings,* but is nevertheless quite distinct therefrom. In *H. communis*, according to Mr. Billings, the shell is sometimes longitudinally striated, which is not the case, so far as observed, in the shells of this species. The opercula are also different. In the operculum of *H. communis* there are but two ridges in the interior. These correspond to the longitudinal ridges of our species as shown in figure 2 *b*. There is also a slight variation in the rate of tapering of the two species. They are, therefore, entirely different. A species of about the same size and form occurs in the Potsdam sandstone of Wisconsin (16th Reg. Rep., p. 135, pl. 6, figs. 30 and 31).

This species occurs abundantly in one of the thin deposits of even-bedded limestone, and one of the bands of limestone conglomerate included among the primordial slates east of Troy, N. Y., commonly associated with *Hyolithes Americanus*, *Obolella desquamata*, *Olenellus asaphoides* and *Conocephalites trilineatus*. The true character of its operculum was first detected by Mr. Billings.

The specimens were collected by the writer.

* Canadian Naturalist, vol. vi, p. 214, December, 1871.

Agnostus nobilis, n. sp.

Head and pygidium of nearly the same size and form, both exceedingly convex. The head is broadly semi-elliptical, wider than long, the length to the breadth about as 5 to 6. Convexity greatest along the median line, reaching its maximum on a straight line joining the posterior angles. From thence the slope is nearly equal to the front and sides. The sides, anterior margin, and part of the posterior margin, abruptly concave, rounded, and slightly incurved. Posterior angles rounded. The posterior outline is slightly concave for a short distance on either side of the middle, leaving a strong, tapering, median projection. The extremity of this projection is truncate, and appears to form a nearly flat articulating face. The head is surrounded by a narrow convex border directed a little downward, of uniform width, or but slightly attenuated on the posterior outline. On either side of the head this border is set off with a row of prominent tubercles from seven to eight in each row. No tubercles have been observed on the extreme front and posterior portions of the border. The surface of the head, including the border, is transversely crossed by numerous faintly impressed lines, curving backward, for the most part invisible to the naked eye.

The pygidium is of equal length and width with the head. The convexity, however, is a trifle greater along the middle, and the anterior angles rather less rounded than the corresponding angles of the head. The greatest convexity occurs at the anterior third of the pygidium. The anterior outline is slightly concave at the middle, and is then feebly rounded in passing outward and backward to the angles. The contour of the sides and posterior margin the same as that of the sides and anterior margin of the head. A narrow marginal border similar to that of the head, though not tuberculated, surrounds the pygidium, terminating on either side of the concave portion of the anterior outline. The surface is covered with delicate lines similar in character and direction to those of the head.

1.* 2.

The two extremities are connected by a single thick thoracic ring. This ring is partly shown in fig. 1. From the appearance of the figure, however, there would seem to be room for

* Fig. 1. A nearly perfect specimen of *Agnostus nobilis*. The posterior limit of the head is not well shown in the figure, but may be made out clearly in the specimen. Fig. 2. Side view of the head of another individual. The tubercles on the border are wanting in this figure owing to their removal on the side of the specimen represented.

a second ring, but this appearance is due to the damaged condition of the head.

Two specimens only of this species have been obtained, one a head with a small portion of the pygidium; the other a nearly perfect individual. The dimensions of the latter are as follows: Length of entire animal ·64 of an inch. Length of head along the median line ·30, width at posterior angles ·36 of an inch. Median length of pygidium ·30, width at anterior angles ·36 of an inch. Width of head and pygidium, at one-third the length of each from their smaller extremities, each ·28 of an inch. Width of thoracic ring ·10 of an inch. This is likewise the width of the concave portion of the pygidium with which it lies in contact. Greatest depth of pygidium ·14 of an inch. Greatest depth of head ·12 of an inch.

The proportions of the other head are slightly different, the length being ·34, the width ·39, and the greatest depth ·14 of an inch. The specimens were found lying close to each other in the same hand fragment of limestone. Occurs in even-bedded limestone east of Troy, N. Y., in the same layer with *Olenellus asaphoides*, *Agnostus lobatus*, *Obolella cælata*, and *O. desquamata*.

Collected by the writer.

This is a remarkably beautiful species of *Agnostus*, its large size, symmetrical form, extreme convexity, and prominently studded head-rim all rendering it a most interesting and conspicuous object. In a fossil so simple in its structure as this, and in which the apparent differences between the opposite extremities of the body are so slight, it is difficult to determine certainly which is the head, and we do not feel quite sure that the part thus referred is really such. Prof. Hall has described under the name of *Agnostus parilis* a species of the same type from the Potsdam sandstone of Wisconsin (16th Reg. Rep., p. 179, pl. x, figs. 23 and 24), but that species is vastly smaller than this one. It differs also in having a small elongated node upon the pygidium along the middle, a plain instead of tuberculated border around the head, and in having the marginal rim of both the head and pygidium proportionally broader at their smaller ends. It lacks, too, the fine surface lines of our species. The proportional depth of the two species is very likely about the same No entire specimens of *A. parilis* have been illustrated, the two extremities having been referred to each other, and no doubt rightly, from their similarity of form. The species is stated to occur near the middle of the formation.

Troy, March 30th, 1872.

ART. LV.—*Descriptions of New Species of Fossils from the Cincinnati Group of Ohio;* by F. B. MEEK.*

ANOMALOCYSTITES (ATELEOCYSTITES?) BALANOIDES M.

THE only specimens of this fossil that I have seen are in a bad state of preservation, being distorted by pressure, and consisting only of the lower portions of the body, and some of the extremely thin segments of the thickened part of the column connecting with the base of the same. One side of the body was evidently flat, or a little concave, and the other convex; and the entire outline, as seen on either of these sides, was probably oblong-suboval; while the lateral margins are distinctly carinated, at least toward the lower part.

Although this species is evidently closely allied to the genera *Anomalocystites* and *Ateleocystites*, I am not positively sure that it would be found to fall strictly into either, if we had the means of comparing its entire structure. It certainly differs conspicuously, at least in its specific characters, from the typical and only known forms of both of these groups. In the first place, it is much larger than *Anomalocystites cornutus*, and has the middle two pieces of its lower range on the flat side proportionally longer; that is, longer than the marginal pieces, instead of the reverse. Its base is also more deeply sinuous on this side than in the New York species. On comparing its convex side with that of *A. cornutus*, we observe still more marked differences, the three principal plates of the lower range in our type being all decidedly longer than wide, instead of the reverse, and the middle plate considerably longer than that on each side of it; while the carinate marginal pieces, which are quite distinctly seen in this view of our species, are scarcely visible on this side of the New York species. There are doubtless also equally great differences in the arrangement and structure of the parts farther up, on both sides, if we had the means of making comparisons of this part of the body.

In size, our species corresponds more nearly with *A. disparilis* from the N. Y. Oriskany sandstone; but from what has already been stated, it will be seen to differ too widely in the form and proportions of its lower range of plates to render a comparison necessary.

Compared with *Ateleocystites Huxleyi* of Billings, the type and only known species of that genus, our species will be found not only to differ in its much greater size, but also in having its base greatly more widely and deeply sinuous on the flat side, for the reception of the column; while its central two

* These fossils are to be fully illustrated in the final report of the Ohio Geological Survey.

pieces taper more rapidly upward, and are longer in proportion to the lateral ones. Its lateral pieces, on the contrary, taper more decidedly downward, and differ in having their lower ends curved inward. The convex side of *A. Huxleyi* and the upper parts of our type being unknown, we have no means of carrying the comparison further; but enough can be seen to show beyond doubt that the two forms are at least clearly distinct specifically.

Whether these several forms belong to one, two, or three genera, it must be evident, I think, to any one accustomed to study these old types of the *Echinodermata*, that in a systematic classification of the *Cystoidea* they will have to stand together in a distinct family, *Anomalocystidæ*, occupying a somewhat analogous position among the various types of that group to that of the family including *Eucheirocrinus* (= *Cheirocrinus* Hall, 1860: not of Eichwald, 1856), among the typical *Crinoidea*.

Locality and position.—Upper part of the hills at Cincinnati, in the Cincinnati group of the Lower Silurian. The best specimen I have seen belongs to the collection of C. B. Dyer, Esq., of Cincinnati. I am also under obligations to Prof. O. C. Marsh of New Haven, for the use of another more crushed specimen of the same or an allied species. Both of the specimens were discovered, I am informed, by G. W. Harper, Esq., of Cincinnati.

Dalmanites Carleyi M.

Small; entire outline unknown, but probably subovate; cephalic shield about twice as wide as long, rounded in front, and more or less nearly straight across behind, thus presenting a somewhat semi-circular outline, exclusive of the produced posterior lateral extremities, which are about as long as the glabella, rather broad at their connection with the cheeks, and tapering rapidly to their posterior ends; glabella wide in front, and rapidly narrowing behind, defined by a moderately distinct furrow on each side, and not very prominent at any point; anterior lobe large, transversely subrhombic in outline; lateral lobes small, and separated by furrows that extend inward so as to leave only a very narrow central space; anterior pair each subtrigonal, and about twice the size of those of the middle pair, which are each transversely ovate, while those of the third or posterior pair are smallest; neck furrow moderately well defined, and continued as posterior marginal furrows of the cheeks, and curving backward a little on the posterior lateral spines; occiputal segment comparatively thick in its antero-posterior diameter at the middle, where it is rather elevated, and rounded convex in the posterior outline; palpebral lobes ascending and narrowing rapidly outward to the summit of the eye; cheeks narrow, and sloping abruptly from the eyes to a

shallow marginal groove; eyes comparatively large, situated full half their antero-posterior diameter from the posterior margins of the cheeks, and elevated somewhat above the height of the glabella, truncato-subconical in form, the visual surface curving around so as to form about three-fourths of a circle at its base; lenses of comparatively moderate size, showing about seven in a vertical row at the middle, and twelve or fourteen in the longest oblique rows. Surface of anterior lobe of glabella showing small, obscur egranulations; other parts of the cephalic shield nearly smooth, or less distinctly granular.

Thorax unknown. A pygidium found in the same association may be described as follows: subtrigonal, rather depressed, as wide as long, or a little wider, very nearly rounded or almost subangular behind, the posterior extremity being a little curved upward; mesial lobe depressed, but a little more convex than the lateral, and of about the same breadth or slightly narrower at the anterior end, and narrowing to the posterior end, which does not reach the margin, composed of about thirteen distinct segments, and two or three other very small obscure ones behind these; lateral lobes separated from the mesial lobe by moderately distinct furrows, and sloping off gently, with slight convexity of outline, to the lateral and posterior margins, showing each about thirteen segments which are not furrowed, and extend very nearly, but not quite, to the margin, the smaller posterior ones being directed very obliquely backward, surface showing rather fine irregular scattering granulations.

Length of cephalic shield, exclusive of the posterior lateral spines, 0·35 inch; including them, about 0·60 inch; breadth, 0·67 inch; antero-posterior diameter of eyes, 0·12 inch; height of same on outer side, 0·08 inch. Length of an associated but detached pygidium of about the corresponding size, 0·42 inch; breadth of do., about 0·48 inch.

I am not positively sure that the pygidium found associated with the cephalic shield here described belongs to the same species; but as several specimens of each have been found in the same bed, and they correspond well in size and surface characters, there is very little reason to doubt that they belong to the same trilobite.

In size and general appearance this species resembles *D. callicephalus* Hall, from the New York Trenton group; but it differs materially in having the posterior lateral angles of the cephalic shield produced into long spines, instead of merely terminating in broad, rounded, wing-like expansions. It also has the eyes proportionally shorter, and more remote from the posterior margins of the cheeks, as well as much more curved around, than represented in the figures of the New York species.

Again, the surface of its cephalic shield is less strongly granulated. There are likewise equally well marked differences in the pygidium found associated with our species, which shows in each lateral lobe thirteen well defined segments, without sulcation; while in *D. callicephalus* these lobes are described as having each only nine segments, that are marked with strong furrows.

Although fully satisfied that the species here described is distinct from *D. callicephalus*, I was in doubt whether or not it might be the same form for which Prof. Hall had proposed the name *Dalmania breviceps* (=*Dalmanites breviceps*),* and consequently withdrew the description from a paper on some Ohio fossils that I had submitted for publication. I observed some important differences in our specimens from the character given in the description of *D. breviceps;* but fearing that these might possibly be due rather to some accidental condition of the specimens of that species, I preferred to wait until a figure of that form should be published. As that has recently been done, and I find, on comparison with this figure, that our specimens show well marked and constant differences, there is no longer any reason for hesitation in regarding them as belonging to distinct species. The differences distinguishing the two forms are the following: in the first place, the anterior lobe of the glabella of our species has a more nearly rhombic form, being much more narrowly rounded at each end; again, it differs in having three well defined pairs of lateral lobes to the glabella, instead of only two, the anterior of these three pairs being as large as both of the others, and each triangular in form. The neck segment of our species likewise differs in being fully twice as thick as that of *D. breviceps*, while its palpebral lobes have an entirely different form, and its eyes are decidedly more strongly curved and farther removed from the posterior margin of the cheeks.

The specific name of this trilobite is given in honor of S. T. Carley, Esq., formerly of Cincinnati, one of the earliest and most successful collectors and students of the Cincinnati fossils.

Locality and position.—Three hundred feet above low-water mark, at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian. The specimens studied and figured belong to the collection of U. P. James, Esq.

Proetus Spurlocki M.

General form, exclusive of the spines of the cephalic shield, ovate-subelliptic, with moderate convexity. Cephalic shield

* The name *Dalmania* having been pre-occupied for a genus of insects, it ought not to be retained for these trilobites. I therefore prefer to follow Prof. Barrande and others in using for the group the name *Dalmanites*.

having the form of half of an ellipse divided through its shorter diameter, its posterior margin being straight, and its anterior narrowly rounded; posterior lateral angles produced into long sharp spines, that extend back nearly or quite the entire length of the thorax; glabella a little less than one-third the breadth of the posterior part of the head, separated from the cheeks on each side by a well defined furrow, but without having the neck furrow behind distinctly marked; other characters of the glabella unknown; eyes sublunate, nearly their own length in advance of the posterior margins of the cheeks.

Thorax apparently shorter than the head, showing in the specimen examined only seven segments (one or two being probably concealed by the slipping backward of the cephalic shield); mesial lobe moderately prominent, scarcely equaling the breadth of the lateral lobes anteriorly, and tapering more rapidly backward, with its segments not arching forward. Lateral lobes less convex than the middle one; pleuræ nearly straight and transverse, and furrowed for a little more than half way out, with their outer extremities merely rounded in front, and nearly rectangular behind, without any distinct backward curvature.

Pygidium subsemicircular, scarcely one-half as long as the cephalic shield, and provided with a smooth flattened margin; mesial lobe moderately prominent, narrower than the lateral, tapering posteriorly, where it terminates rather abruptly, without passing quite upon the flattened margin, showing only very obscure traces of five or six segments on its anterior half. Lateral lobes more depressed than the mesial one, and with flattened margins rather more than one-third the breadth at the anterior end of each, and each showing obscure traces of six or seven furrowed segments.

Entire surface smooth.

Length of a specimen apparently very slightly shortened by the slipping of the cephalic shield a little back upon the thorax, 0·33 inch; breadth at the widest part across the posterior part of the head, 0·25 inch; length of head, 0·27 inch; do. of pygidium, 0·11 inch.

Until I saw the published figure of *Proetus parviusculus* Hall, I had thought it possible that this might be the same, although it did not seem to agree in several characters with those mentioned in the previously issued description of that species. On comparing it with the figure of that form, however, it will at once be seen to present well marked differences. In the first place its cephalic shield is decidedly longer in proportion to its breadth, and more narrowly rounded in front; while the posterior lateral spines of its cheeks are nearly or quite twice the proportional length of those in *P. parviusculus*. Its eyes are

also placed decidedly farther forward, and its neck segment is much less distinctly defined. When we come to its thorax, we also see equally well marked differences, its pleuræ not being curved backward and falcate as in that species, nor having their furrows extending so far outward. It almost certainly has one or two segments less, though the slight slipping backward of the cephalic shield leaves some little room for doubt on this point. I have, however, also an inferior specimen before me, belonging to the collection of Dr. H. H. Hill of Cincinnati, believed to belong to this species, and this certainly has only eight thoracic segments. Again, the pygidium of our species differs in having distinctly flattened, smooth, and very obscure furrowed segments on the lateral lobes, that do not extend outward upon this border, while on that of *P. parviusculus* the segments are strongly defined, without furrows, and extend very nearly or quite to the border, so as scarcely to leave any flattened margin.

The specific name is given in honor of T. W. Spurlock, Esq., of Cincinnati, who discovered some of the new fossils loaned to the Ohio Survey, and is well known in that city for his long devotion to the study of the natural sciences.

Locality and position.—Cincinnati group of the Lower Silurian, at a horizon of about 100 feet below the tops of the hills, at Cincinnati, Ohio. Mr. Dyer's collection.

ART. LVI.—*On the Age of the Copper-bearing Rocks of Lake Superior;* by T. B. BROOKS and R. PUMPELLY.

SOME observations made by us in the southwestern part of the Upper Peninsula of Michigan demonstrate a wide difference in age between the Cupriferous series of sandstones, conglomerates and melaphyres on the one hand, and the Lower Silurian sandstone, with which they have generally been considered as nearly identical in age, on the other. Both series have been referred by Foster and Whitney to the Potsdam, by Sir William Logan to the Chazy, while Mr. Bell of the Canadian Corps considers the Cupriferous series to be Triassic, the latter agreeing herein with Jackson and with the view afterwards abandoned by Owen.

The principal facts on the south shore of Lake Superior are as follows: A series of red sandstone and shales, lying everywhere nearly horizontally, borders the Michigan shore between the Saulte St. Mary and Bête Gris Bay on Keweenaw Point. From the former place to west of Grand Island, this sandstone is overlaid on the south by other Silurian rocks, and between

Grand Island and Marquette the whole series sweeps around to the southwest, on its way to form the western, as it had hitherto formed the northern, rim of the great Michigan basin. Where this southwesterly bend begins, the outcrop-line of the sandstone divides, and from Marquette westward we find, with short interruptions, the sandstone beds flanking the northern foot of the Huron mountains, and dipping gently, 5° to 15°, toward the trough of Lake Superior.

In this part of its course, where it may be said to belong to the Lake Superior basin proper, it forms a marginal band along the lake shore, varying in breadth from a few rods to one or two miles. But west of the Huron Islands it widens with the southwesterly curving of the topographical axis of the Huron mountains, and fills with its horizontal strata the broad trough lying between these hills and the range of copper-bearing rocks of Keweenaw Point. In this depression there still remain one or two hills formed by remnants of the younger Trenton limestone. The trough, partly occupied by the waters of Keweenaw Bay, has for its western slope the beds of this Lower Silurian sandstone, which rise, at what seems to be the original angle of deposition, from the waters of the bay to form the broad belt of nearly level sandstone country which makes up the eastern half of Keweenaw Point.

At the western edge of this belt, its nearly horozontal strata abut against the steep face of a wall formed by the upturned edge of beds of the Cupriferous series of melaphyre and conglomerate, which dip away from the sandstone at angles of 40°–60°, according to geographical position. This sharply defined and often nearly vertical plane of contact, having been seen by the earlier geologists at several points along a distance of many miles, and having been found to be often occupied by a thick bed of chloritic fluccan, which was looked upon as the product of faulting motion, was considered as a dislocation.

This idea seemed to gain corroboration in the fact that, on the western side of Keweenaw Point, sandstones bearing considerable resemblance to those of the eastern horizontal beds occur, apparently conformably overlying the Cupriferous series.* Both sandstones came to be considered as identical in age, and as forming the upper member of the group.

There were many circumstances which made it difficult for us to accept this conclusion. One obstacle lay in the enormous amount of dislocation required; for instance, at Portage Lake, where the strata of the Cupriferous series, with an actual thickness of several miles, dip away from the supposed *longitudinal* fault at an angle of about 60°.

*It is not yet known whether these sandstones on the west side of Keweenaw Point are upper members of the Cupriferous series or belong to the Lower Silurian.

Again, there are at least two patches of sandstone lying on the upturned melaphyre beds near Houghton, though it was not easy to prove that they were not brought thither by glacial action. Mr. Alexander Agassiz informs me that he has found in the horizontal sandstones near this so-called "fault," abundant pebbles of the melaphyre and conglomerate of the Cupriferous series.

Sir William Logan hints at a similar doubt as to the proximate equivalence in age of these two series of rocks.* During last autumn, traveling sometimes together and sometimes apart, we made a reconnaissance of the country between Bad river in Wisconsin and the middle branch of the Ontonagon, east of Lake Gogebic† in Michigan. Our route was chiefly confined to the surface of the upper member of the Michigan Azoic, which we have provisionally considered to be the equivalent of the Huronian.

From Penokie Gap, on Bad river, to near Lake Gogebic—a distance of nearly sixty miles—the quartzites and schists of this formation are tilted at high angles and form a belt one-fourth to one-half mile in width, bordered on the south by Laurentian gneiss and schists. On the north, it is everywhere overlaid by the bedded melaphyre (containing interstratified sandstones) of the Cupriferous series. These form ridges and peaks which rise 200 to 300 feet above the surface of the Huronian belt.

These ridges, forming the "South Mineral Range," unite at their western end with the Mineral Range proper, which forms really through its whole length the tongue of land known as Keweenaw Point. Between these two ranges lies the southwestern part of the Silurian trough, which has been mentioned before as extending inland from Keweenaw Bay.

Here, as there, it is filled with the horizontally stratified Silurian sandstone, forming a generally level country. For a distance of nearly thirty miles, between the Montreal river in Town 47 and Lake Gogebic, we found the Cupriferous series apparently conforming in strike and dip with the Huronian schists, and both uniformly dipping to the north at angles of 50°–70°.‡ But in approaching Lake Gogebic from the west, we find that erosion of Silurian or pre-Silurian age has made a deep indentation entirely across the Cupriferous series and the Huronian, and into the Laurentian, so that at a short distance

* Geol. of Canada, page 85. And again in Geol. Survey of Canada, Rep. of Prog. 1863–67, pp. 472–475. In the last mentioned place, he protests strongly against the idea that the copper-bearing rocks of Lake Superior are Triassic.

† Wrongly written Agogebic on many maps.

‡ We observed several dips in the Huronian of 25°–40°, while in the overlying Cupriferous series none lower than 50° were found. While this may point toward non-conformability, the greater dip of the overlying beds would make it probable that the lower dips were of a local character and due to minor undulations in the Huronian.

west of the lake these rocks end in steep and high declivities, at the base of which lies the level country of the Silurian sandstone, in which is cut the basin of the lake. From this point eastward, this ancient erosion had made great inroads upon the continuity of the Cupriferous and older rocks before the deposition of the Silurian sandstone. The melaphyre ridges are broken into knobs, or are wanting, and no Huronian was found as far as the Ontonagon river, seven miles away, and the limit of our observations.

On this river, in the center of the northwest quarter of Sec. 13, Town 46, Range 41, the Silurian sandstone was found exposed in cliffs 50–60 feet high. The strata are horizontal, or at most have a barely perceptible tendency to a northerly dip. About 150 steps from the base of this cliff, there are outcrops of Laurentian schists whose bedding trends N.E. toward the cliff of horizontal sandstone, and dips 45°–60° S.E. The nearest observed outcrop of the Cupriferous series is in the S.E. corner of Sec. 5, about four miles distant. It is a characteristic amygdaloidal melaphyre, whose bedding planes strike nearly E. and W., and dip 50° to N. In general terms, the conclusions we are drawn to are these:

I. The Cupriferous series was formed before the tilting of the Huronian beds upon which it rests conformably, and consequently before the elevation of the great Azoic area,* whose existence during the Potsdam period pre-determined the Silurian basins of Michigan and Lake Superior.

II. After the elevation of these rocks, and after they had assumed their essential lithological characteristics, came the deposition of the sandstone, and its accompanying shales, as products of the erosion of these older rocks, and containing fossils which show them to belong to the Lower Silurian, though it is still uncertain whether they should be referred to the Potsdam, Calciferous or Chazy. The question would still seem to be an open one, whether the Cupriferous series is not more nearly related in point of time to the Huronian than to the Silurian.

Our observations have detected a lack of conformability between the Laurentian and Huronian at several points on the Upper Peninsula. On the other hand, in the region we have been discussing, which is the only one where the Huronian and Cupriferous are seen in contact, there seems to be a well-marked concordance between these two. There is abundant evidence on the Upper Peninsula that the Silurian sandstone was not deposited until after the Huronian beds had assumed both their present structural position and lithological characteristics, and after they had undergone an enormous amount of erosion.

* Islands of Laurentian gneiss, etc., existed in the Huronian sea over parts of this area.

Some of the most salient topographical features of the Upper Menomonee had been sculptured to the depth of two hundred feet or more before that time, and were afterward buried and wholly obliterated by the Lower Silurian deposits, and have been partially restored by the subsequent erosion to which that valley now owes its features. We now find ridges, consisting of the nearly vertical beds of Huronian quartzite and iron ores, capped with the horizontal sandstone, of which last patches still remain in place on the end and side declivities. Where the sandstone was deposited at the base of these cliffs, we find it consisting largely of a breccia of the debris of quartzite and iron ore, identical in character with these substances in the unbroken ledge. It would probably be perfectly safe to apply the same remark to the Cupriferous series. Its members were formed, as we have seen in the previous pages, before the elevation of the Huronian rocks. The deposition of the Silurian rocks bordering on Lake Superior should seem to have taken place during the progress of a gradual depression, which caused the coast line of that part of the Silurian sea to be represented by the bold cliffs of the interior of the Azoic land. In the eastern declivity of the mineral range of Keweenaw Point, we may see, then, one of these shore cliffs instead of the exposed side of a gigantic fault.

It is probably to this process of deposition of the Silurian sandstone over an area, which after having undergone an enormous amount of erosion was being gradually submerged, that we owe the absence of outcrops of the Cupriferous series beneath the sandstone at so many points on the south shore. It would be difficult indeed to account for their total absence at L'Anse, for instance, by supposing them to have thinned out, when at a distance of 18 miles they have a thickness measured by miles, a thickness they exhibit wherever they are known, at points hundreds of miles apart on the north and south shores.

ART. LVII.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXII.—*On Radiata from the Coast of North Carolina;* by A. E. VERRILL.

POLYPS; ALCYONARIA.

Leptogorgia Carolinensis, sp. nov.

Corallum somewhat flabelliform, branching nearly in one plane, but the branches are not normally coalescent. The large branches are irregularly dichotomous, but the smaller ones are irregularly pinnate and sometimes partially bipinnate; the branchlets are alternate and diverge at a wide angle, sometimes nearly at right angles, and are usually from ·25 to ·50

of an inch apart, and generally not more than ·5 to 1 inch long before dividing. The branches are rather stout, terete or subcompressed, usually but little crooked. The branchlets are terete, slender, but not elongated, rather rigid when dry, slightly tapering to the end. The axis is dark, dull wood-brown in the larger branches; translucent amber-yellow in the branchlets; light yellowish wood-color at the base. The polyp-cells are small and usually very little raised, arranged in four to six irregular alternating rows on the sides of the large branches, and in two to four rows on the smaller ones, leaving only a narrow naked median space, along which there is generally a distinct line corresponding to the large longitudinal ducts.

Color of the cœnenchyma bright brick-red. Height 12 inches, breadth about the same; diameter of the larger branches, ·15 to ·20 of an inch; of the branchlets, ·05 to ·07.

The spicula of the cœnenchyma are light red, and consist of minute "double-spindles" of several degrees of stoutness, but mostly rather short, thick, and blunt. The largest and stoutest ones are ·096^{mm} by ·042, ·096 by ·036, ·090 by ·048; they have a very narrow naked median zone, and two close whorls and a terminal cluster of rough warts on each end; many other smaller and shorter ones have but one whorl and a terminal cluster of warts. The most slender ones are small and acute at the ends, with a wide naked zone and with two or three more distinct whorls of few warts on each end; they measure ·132^{mm} by ·030, to ·120 by ·036. There are also many forms of more minute spicula. The polyp-spicula are bright red, slightly spinulose, and vary in size from ·096^{mm} by ·018 to ·072 by ·010.

Near Fort Macon, N. C.,—Lieut. C. S. Smith, U. S. A.; Dr. A. S. Packard; Dr. H. C. Yarrow, U. S. A.

In the largest specimen four main branches of nearly equal size spring directly from the base.

Leptogorgia setacea Verrill.

Gorgonia setacea Pallas, Elenchus Zoöph., p. 182, 1756 (*non* Dana).
Pterogorgia simplex Val., Comptes-rendus, xli, p. 13.
Xiphigorgia setacea Edw. and Haime, Coralliaires, vol. i, p. 172, 1857.

Corallum long, slender, flexible, usually undivided, if not always so, of nearly uniform size throughout, slightly flattened, owing to a thickening of the cœnenchyma on the polypiferous margins, the middle of the broad sides being smooth. Cells rather large, oblong, raised on broad, low, rounded verrucæ, which form either a single row or two alternating rows on each margin. Axis black, slender, flexible, terete, of nearly uniform size throughout. Color light yellow and purple, the smooth median bands yellow centrally; the verrucæ deep purple, with a yellow area around the cells.

Length 56 inches; greatest diameter ·08 by ·10 of an inch.

The spicula of the cœnenchyma are bright purple and pale yellow, and consist of comparatively large, mostly rather stout, blunt, closely warted double-spindles, with a smaller number of slender, acute ones and some small, rough, glomerate forms. The larger and stouter spicula have a narrow naked zone, with two or three close whorls of spinulose warts, and a rounded terminal cluster on each end; they measure ·144^{mm} by ·048, ·132 by ·060, ·120 by ·060, ·114 by ·048, ·108 by ·036. The longest slender spicula are thin, tapering regularly to the acute ends, and have a rather wide naked zone, with three and sometimes four whorls of minute warts on each end; the largest are ·144^{mm} by ·036, ·132 by ·048, ·132 by ·036, ·132 by ·042. The polyp-spicula are bright yellow, minute, slightly spinulose, oblong or slender, simple spindles, mostly varying in size from ·114 by ·018 to ·090 by ·009.

Near Fort Macon, N. C.,—Dr. H. C. Yarrow.

This species is of great interest both on account of its singular form, and because it has always been an imperfectly known species, without a definite location, either geographically or systematically. Pallas stated that his specimens were attached to American shells, but with one exception the axis alone remained, and no additional information has been published in regard to its habitat since his time, so far as known to me.

The species described by Prof. Dana, under the same specific name, has a calcareous axis and belongs to *Juncella*.

Anthopodium, gen. nov.

Corallum with an encrusting, firm cœnenchyma, from which arise prominent, tubular verrucæ, with rather large polyps at the summit. The surface of the cœnenchyma and verrucæ is minutely granulous with rough irregular spicula, closely united together. The spicula are of many forms and sizes, and are remarkable for their irregularity and roughness; the most prominent kinds are very roughly warted and spinulose oblong forms, and rougher lacerate club-shaped ones, many of which are flattened at the large end. Besides these there are numerous rudely spinulose spindles, and an abundance of the small, short, glomerate kinds.

This genus is allied to *Telesto* on one side and *Callipodium* V. on the other. It resembles the latter somewhat in general appearance and mode of growth, but has very different spicula; to the former it is somewhat allied in the structure of the cœnenchyma and polyp-tubes, and especially in the interlocking of the rough spicula, but the spicula are very different in structure; the walls are thicker and more rigid; and the mode of growth quite different.

Anthopodium rubens V., sp. nov.

Corallum encrusting, creeping over the dead axis of *Leptogorgia* and forming a continuous, thin, firm, finely granulous crust, from which the elongated verrucæ arise nearly at right angles, though usually inclined upward. The polyp-cells are large, at the summit of the tubular and nearly cylindrical verrucæ, which are variable in height and are much crowded in some parts and irregularly scattered in others; their surface is finely granulous, with minute rough spicula. Height of the longest verrucæ ·28 of an inch; diameter ·06. Color, uniform light red.

The spicula of the cœnenchyma and verrucæ are light but bright red; the larger ones are irregularly oblong, blunt at the ends, and covered throughout with rough, often lacerate, spinulose warts; some of these were ·288^{mm} by ·084, ·264 by ·072, ·228 by ·096, ·216 by ·084. With these there are many irregular, rudely spinulose, acute spindles of about the same length, but more slender, measuring ·204 by ·048, ·192 by ·060. There are many smaller obtuse, fusiform, oblong and glomerate spicula, of various sizes, covered with rough spinulose warts, like the larger ones. The club-shaped spicula are less numerous, and usually smaller than the largest oblong ones, but are similarly covered with rude spinules. There are also many small oblong spicula, with a smooth naked median zone, and bearing a few small acute spinules on each end, and other similar ones with small distant spinules on all parts; some of these are irregularly branched, either with three, four, five, or more points, but regular crosses are rare. The polyp-spicula are deep red, simple, fusiform, or club-shaped spicula, with a few irregular minute spinules, or with the surface merely uneven; they are about ·156 long and ·036 in diameter.

Fort Macon, N. C.,—Prof. E. S. Morse.

In addition to the preceding the following species of Alcyonaria were collected at Fort Macon by Dr. H. C. Yarrow.

Renilla reniformis Cuvier (Ellis sp.).

Leptogorgia virgulata Edw. and Haime (Lamk. sp.).

Titanideum suberosum V. (Ellis sp.)

Telesto fruticulosa Dana.

Actinaria.

Calliactis sol Verrill.

Cereus sol (*pars*) Verrill, Bulletin Mus. Comp. Zoöl., i, p. 58, 1864; Memoirs Boston Soc. Nat. Hist., i, p. 24, 1864.

Dr. Yarrow has sent numerous specimens of this species from Fort Macon, and also a colored drawing, showing the appearance while living. The base, as in the other species of the genus, is dilated, with a thin border, often expanding into lobes

and radiately lined; just above the base there are two circles of conspicuous pores. The tentacles are numerous, crowded together toward the margin, in length more than half the diameter of the disk (about ·5 of an inch in the figured specimen), moderately slender and scarcely acute. The lobes of the mouth are bright yellow; a broad circle of purple surrounds the mouth; the rest of the disk is light blue with darker radii; the tentacles are bright orange-red; the body is light purplish-red, with dark red blotches and longitudinal streaks, especially near the base. Other varieties of coloration occur.

It lives like the other species of the genus, adhering to dead shells inhabited by hermit-crabs. A variety of this, or an allied species, is abundant on the eel-grass and algæ.

Paractis rapiformis Edw. and Haime.

Actinia rapiformis Lesueur, Jour. Acad. Nat. Sci. Phila., i, p. 171, 1817; Verrill, Mem. Boston Soc. Nat. Hist., i, p. 35, 1864.

This species, still very imperfectly known, was collected in considerable numbers by Dr. Yarrow, who found them thrown on the beach after south-west storms, resembling, when in that condition, a boiled onion, or something of that sort. According to Dr. Yarrow's notes and drawing, when expanded the body is elongated and very changeable in form, up to three inches or more long and 1·5 in diameter; the surface in expansion is vertically sulcated or fluted, nearly smooth. The body is pinkish flesh-color and translucent when adult, darker and transparent in the young. The tentacles are numerous, rather short, tapering, sub-equal, pale greenish olive, with a pale orange line along their insertion, and a blackish band around the base, connected with a dark line radiating from the mouth. The mouth was frequently everted, but no acontia were observed. Toward the summit the surface of the body is minutely wrinkled and capable of attaching sand to itself; close to the tentacles it is thinner and smooth. This species has once been found on the shore of Long Island Sound, near New Haven Light.

The following species were also collected by Dr. Yarrow:

Sagartia leucolena V., Proc. Bost. Soc. Nat. Hist., x, p. 336, 1865.

Aulactinia capitata V., (Ag. MSS.) Mem. Bost. Soc., N. H., i, p. 20, 1864.

Cladactis cavernata V., (Bosc) Trans. Conn. Acad., i, p. 473.

Paranthea pallida V., (Ag. sp.) Proc. Essex Inst., v, p. 322.

Cerianthus Americanus V., Mem. Bost. Soc., N. H., i, p. 32.

Madreporaria.

Astrangia Danæ Ag., 1847.

The *Astrangia astræiformis* Edw. and Haime (1848) is a form of this species with the cells crowded together, which occurs in

some New England specimens, as well as in southern ones, although less frequently than in the latter. I have hitherto considered the two forms distinct species, but am now in possession of specimens from Vineyard Sound, Mass., which induce me to unite them.

Oculina arbuscula V., Mem. Bost. Soc., N. H., i, p. 40.
O. implicata V., op. cit., p. 41.

ACALEPHS.*

Physalia Arethusa Til.
Parypha cristata Ag. (McCrady sp.) Piles of wharf.
Hydractinia polyclina Ag. Common.
Aglaophenia trifida Ag. Very common.
Dynamena cornicina McCrady.
Diphasia sp.
Sertularia Carolinensis V., sp. nov.

Stem long and slender, very flexible, giving off numerous slender, falcate branches, one to three inches long, arranged spirally. The branches are mostly simply pinnate, but some of the lower ones are bipinnate, with the branchlets falcate. The hydroid cells are small, unequally alterate, rather closely appressed, with an oblique, slightly bilobed aperture. The capsules are stout elliptical, about four times as long as the hydroid cells, and with the breadth about one third of the length, swollen in the middle, narrowed toward the aperture, which is nearly simple, with the margin slightly uneven. Height about one foot.

ECHINODERMS.

Thyone Briareus Sel. (Lesueur sp.) Abundant.
Pentamera pulcherrima Ayres. Four specimens.
Thyonella gemmata V., gen. nov. (Pourt. sp.)

Colochirus gemmatus Pourtales, Proc. Am. Assoc., 1851, p. 11.
Thyonidium gemmatum Selenka, Zeitschrift für Wissenschaftl. Zoöl., xvii, 1867, p. 345, tab. xix, figs. 100, 101.

This species differs so much in structure from the typical species of *Thyonidium* that it should form the type of a distinct genus. It has but ten tentacles, of which the two inferior ones are smaller, while in *Thyonidium* there are twenty tentacles, two small ones alternating with two large ones. The test in the present species is thicker and filled with an usually large amount of calcareous plates. Other differences are to be found in the oral plates, the genital organs, etc.

Mœra Atropos Mich., 1855. Common.

The name *Mœra* is preoccupied for a genus of Crustacea (Leach, 1813); the name of the present genus must, therefore, be changed.

Mellita pentapora Lütk. Brazil to Vineyard Sound, Mass.

* All the Acalephs and Echinoderms, unless otherwise stated, were collected by Dr. H. C. Yarrow.

Lytechinus variegatus A. Ag. (Lamk. sp.) Common.
This species is widely distributed, occurring from Bahia, Brazil and the West Indies to Bermuda and the coast of New Jersey, at Great Egg Harbor.
Echinocidaris punctulata Desml. Common.
Gulf of Mexico to Long I. Sound and Vineyard Sound.
Asterias arenicola Stimp. Common.
Florida to Massachusetts Bay.
Astropecten articulatus Lütk. (Say sp.) Not common.
Luidia clathrata Lütk. (Say sp.) Common.
Ophiura olivacea Lym. (Ayres sp.) Common.
South Carolina to Vineyard Sound.
Ophiophragmus Wurdemanni Lym. Common, Dr. E. Coues.
Ophiothrix angulata Ayres. Common in cavities of sponges.

ART. LVIII.—*On a Meteoric Iron lately found in El Dorado county, California;* by CHARLES UPHAM SHEPARD, Sr., Massachusetts Professor of Natural History in Amherst College.

FOR my knowledge of the meteoric iron of El Dorado Co., I am indebted to Mr. Alfred Stebbins, librarian of the Mercantile Library Association of San Francisco. A letter from him, dated April 26th, inclosed a few grams of turnings obtained during the separation of a slice of the mass destined for the collection of the geological survey now in progress under the direction of Prof. Whitney.

The mass is described by Mr. Stebbins as having the size and shape of a man's head. It was found in a field, and, as usual, was first taken to a blacksmith's shop, where it was soon found to be an unmanageable subject for working, and hence, fortunately, found its way into scientific hands. Its surface possesses the indentations common to these bodies—the crust or coating being partially oxidized. It weighs eighty-five pounds.

I find the turnings to have a specific gravity of 7·80, which may perhaps be a trifle above what the mass possesses, as it is presumable that the turnings have suffered a slight condensation in the process of separation.

The fragments sent are free from all traces of sulphur. A single analysis upon one gram has afforded me,

Iron,	88·02
Nickel,	8·88
Insoluble, consisting of a mixture of Fe and Fe, with minute silvery particles of supposed phosphor-metals (Schreibersite)	3·50
	100·40

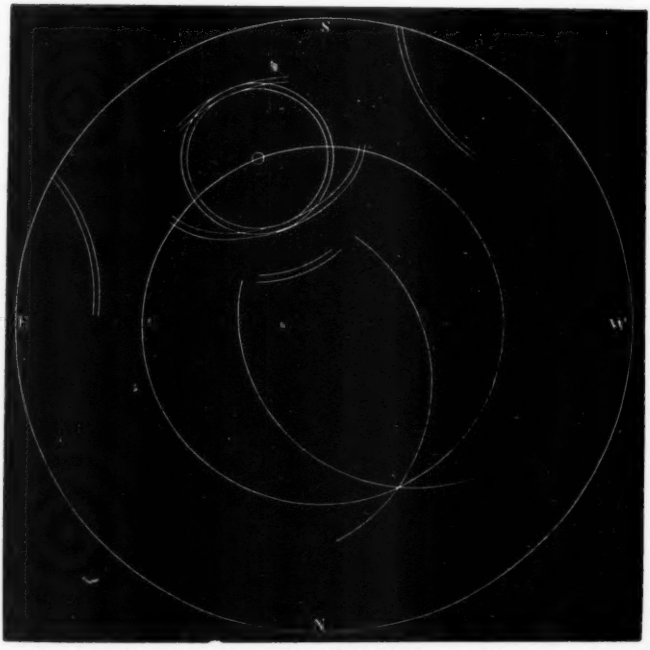
The amount of material at command was too small to search for the other metals commonly found in meteoric irons.

Amherst, May 6, 1872.

ART. LIX.—*On a Solar Halo;* by Prof. WILLIAM WOOLSEY JOHNSON, of Kenyon College, Gambier, Ohio.

THE accompanying diagram represents a combination of solar halos witnessed by myself and others at Gambier on the morning of March 2nd, the sun having an altitude of about 40°.

The double circles represent prismatic halos, the single circles white ones. The halo of 22° and its contact arcs were red on their inner edges. The short arc above and the lateral arcs were blue on the inner edge. The points of contact on the halo of 22° were intensely bright. The upper contact arc was plainly elliptical in form, the lower too short to exhibit decided curvature.



The lateral arcs possessed the brightness and apparently about the curvature of the ordinary rainbow. Each rose above the horizon to a height equal to $\frac{3}{5}$ of its radius, leaving the center depressed about $\frac{2}{5}$ of a radius below the horizon. The diagram being first constructed upon a globe, it appeared probable that the centres were situated upon the great circle of which the sun is the pole, and at distances of 120° from each other and from the culminating point of this circle.

Gambier, O., March 25, 1872.

ART. LX.—*On Molecular and Cosmical Physics;* by W. A. NORTON.

[Continued from page 340.]

4. THE electric envelopes of the two molecules effectively attract each other at all distances greater than *Oa*, or thereabouts. Beyond *Oc*, or within the sphere of the outer repulsion, this effective attraction becomes very feeble, and the repulsion is chiefly heat-repulsion.

It is assumed, throughout the investigation, that the value of r is the same for the receptive as for the active molecule; whereas it is undoubtedly greater; but the only general result, worthy of note, that can follow from any error committed in making this assumption is, that the intensity of the molecular heat-repulsion will be less, as compared with that of the effective attraction exerted by the one envelope upon the other, and hence that the amount of derived heat-pulses required, in coöperation with the natural heat-repulsion, to neutralize this attraction, will be greater.

5. The extraneous heat that is received by the molecules of the body, constitutes a series of repulsive impulses over and above those naturally exerted by the molecules. They have a direct tendency to lower the curve of molecular action at all points—thus increasing *Oa*, diminishing *Oc*, *ac*, and *bm*, and increasing *dn*.

6. The extraneous heat-impulses received have also a certain indirect effect. They urge each molecular envelope farther from the central nucleus, and thus alter the ratio $\frac{n}{m}$; that is, a certain portion of the living force of the heat-pulses is expended in this act, to be afterward given out as the temperature falls. The direct tendency of this recess of the envelope is to diminish the values of both n and m, since its distance from both the center of attraction and center of repulsion is increased. But inasmuch, as we have seen (p. 337), that the latter center lies nearest the envelope, the proportional decrease will be greater for m than for n, and thus the value of $\frac{n}{m}$ should be augmented, and the curve of molecular action will tend to rise at all points, and expand—*Oa* diminishing, and *Oc* increasing. The curve then tends to fall from the direct action of the heat-pulses, and rise from their indirect action in raising the molecular envelopes; and the actual result should be the difference of these two tendencies. We may accordingly expect that heat may in some instances augment the effective attraction of cohe-

sion between molecules. It in reality has this effect upon iron and india-rubber, at ordinary temperatures, and upon water at temperatures below that of maximum density (39° F.).

7. The distance of a molecular envelope from the atom with which it is associated may be increased by augmented attractive impulses exerted upon it from another molecule, as well as by repulsive heat-impulses taking effect from below. The effect of such recess of the envelope from the atom upon the molecular forces, and upon the curve of effective molecular action will, in general, be the same in either case.

8. The effective attraction which the electric envelopes of two contiguous molecules exercise upon each other, at all distances greater than *Oa*, or thereabouts (p. 339), increases in proportion as the distance becomes less and approximates more nearly to *Oa*. It follows from this that the molecular envelopes should be more expanded, that is, be farther from the atoms which they surround, in the solid and liquid than in the gaseous state of bodies; also more expanded in the interior of bodies than at their surfaces.

9. We have seen (p. 440) that the direct tendency of an expansion of a molecular envelope, from whichever of the two causes assigned it may arise, is to augment the range of effective molecular attraction, and increase the maximum value of the attraction. But an opposite tendency to this is at the same time in operation, which results from an increase in the quantity of luminiferous ether lying below the envelope, by reason of the mere fact of the recess of the envelope from the central atom, and also, when this recess is effected by heat-waves, because of the momentary condensation of the ether that attends the reflection of a portion of the wave-force from the central atom. We cannot decide, in a given case, which of these two tendencies will prevail over the other; but it may be seen that the former tendency is most likely to prevail in the more condensed state of the envelope that occurs in the gaseous condition, and at the surfaces of bodies, and the latter in the more expanded state that occurs within solids and liquids. Upon this idea we will term the corresponding molecular conditions *primary* and *secondary*. We are then to look for the secondary condition in solids and liquids; and for a tendency toward the other as the molecular envelopes contract with falling temperature. We should at the same time observe that the secondary tendency is reinforced by the direct repulsive action exerted by the heat-pulses upon the molecules, while the primary is antagonistic to this repulsive action. It is, therefore, to be expected that the primary molecular condition in which a rise of temperature will be attended with an augmentation of tenacity, and a possible contractile action, will be much less likely to occur than the

opposite condition. Now, as a matter of fact, the tenacity of the great majority of solids and liquids decreases as their temperature rises; which shows that they are in the secondary molecular state. But wrought iron and india-rubber are exceptions among solids, and water below the temperature of 39° F. among liquids. For heat contracts india-rubber and water (below 39° F.); and the tensile strength of bar-iron augments as the temperature rises, until it reaches about 500° F. Beyond this a farther rise of temperature has the opposite effect. From this we may infer that bar iron in cooling, from a high temperature, passes back from the secondary into the primary condition at about 500°. Water does the same at 39°. The temperature at which the change occurs in india-rubber is not known.

10. We have now distinctly recognized the important theoretical principle, that *primitive molecules are subject to a change of physical condition, with varying circumstances; and that this change consists in a recess of the molecular envelope from the central atom, or an approach toward it, and is attended with a change in the intensities of the several molecular forces exerted by the molecule at a given distance, and in that of the effective molecular action at any supposed distance.* This principle furnishes the key to the explanation of a multitude of general and special phenomena, which have hitherto remained inexplicable, on the prevalent notion that the atoms of bodies have certain inherent, unvarying forces—repulsive at one distance and attractive at another, or indeed upon any supposition of vibratory or other modes of atomic motion as sources of special forces.

It is important to observe here, that this change of the physical and mechanical condition of molecules, may, in special cases, be either *transitory* or *permanent;* and that any change effected may either wholly or only partially pass off when the inciting cause has ceased to act. This may be seen on attentively considering the change in the condition and extent of the portion of the ethereal atmosphere of a molecule lying below the envelope, that attends the expansion or contraction of the envelope from either of the causes that have been assigned. It may be seen that the disturbed envelope may return to its original position, or more probably may stop short of it more or less.

11. These principles serve to explain the distinction between perfect and imperfect *elasticity.* It has been conclusively established by the experiments of Hodgkinson, Chevandier and Wertheim, and others, that many, and probably the great majority of solids, when relieved of any strain to which they may have been exposed, do not entirely recover themselves, but have a certain *set;* which, from being very minute when it first

becomes measurable, may be made to increase by exceedingly small amounts, by giving small increments to the force by which the strain is produced. Now it is plainly impossible that any mass of molecules, simple or compound, constituting a solid body, can be made to assume an indefinite series of positions of equilibrium, differing very slightly from each other, unless the effective forces exerted by the molecules at a given distance experience some change; and such changes cannot take place, in the mutual actions of compound molecules, except as the result of minute changes in the mutual actions, at a given distance, of their constituent primitive molecules. The defect of elasticity noted must then be attributable to some change in the physical and mechanical condition of the primitive molecules, induced by the strain. Also, if any solid is perfectly elastic, for the particular degree of strain to which it may be exposed, it must be because its primitive molecules do not undergo any permanent change attended with a diminution in the molecular actions that are opposed to the extraneous force.

In accordance with the general theoretical principles stated above, solid bodies are not perfectly elastic, except for small forces of distortion, and consequent small displacements in the relative positions of the molecules, because their molecular envelopes expand, or contract, with the displacements produced, and the molecular reactions are diminished in consequence. Highly elastic substances (glass, ivory, &c.) should then be such as do not undergo any marked change of molecular condition when considerable displacements are produced. Now it appears, as a result of calculation, that when the molecular ratio $\frac{n}{m}$ (p. 338) has the value 6·9,* the effective attraction exerted by one envelope upon another remains very nearly the same for considerable augmentations or diminutions in the distance between them, about the natural position of equilibrium (the point a in the curve of molecular action, p. 339); also that when the ratio $\frac{n}{m}$ is greater than 6·9, the corresponding effective attraction increases, from any distance less than Oa, fig. 4, to a certain distance greater than Oa; and that when the same ratio is less than 6·9, the attraction in question increases, from any distance greater than Oa, to a certain distance less than Oa. Thus the maximum value of this attraction is at the distance Oa when $\frac{n}{m}=6{\cdot}9$, at a greater distance when $\frac{n}{m}>6{\cdot}9$, and at a less distance when $\frac{n}{m}<6{\cdot}9$. This will appear on consulting the following table, giving the results of the calculations.

* The more accurate value is 6·7, in this and the following cases.

Effective attractions between contiguous molecular envelopes.

$n=5{\cdot}143m$		$n=6{\cdot}5m$		$n=6{\cdot}9m$		$n=7m$		$n=7{\cdot}3m$		$n=7{\cdot}576m$		$n=8m$		$n=12{\cdot}41m$	
x	f'	x	f'	x	f'	x	f'	x	f'	x	f'	x	f'	x	f'
r	0·286	r	0·625	0·8r	0·567	0·7r	0·381	0·7r	0·485	0·6r	0·183				
1·3r	0·372	1·1r	0·648	0·9r	0·677	0·8r	0·598	0·8r	0·691	0·7r	0·581	0·6r	0·514	0·4r	0·081
1·5r	0·379	1·2r*	0·649	r	0·725	0·9r	0·704	0·9r	0·787	0·8r	0·776	0·7r	0·727	0·5r	1·515
1·6r	0·371	1·3r	0·637	1·1r*	0·738	r	0·750	0·95r	0·811	0·9r	0·874	0·8r	0·906	0·55r*	1·860
1·7r	0·360	1·4r	0·618	1·2r	0·732	1·05r*	0·757	r*	0·825	0·95r*	0·884	0·85r*	0·954	0·6r	2·070
1·8r	0·347	1·5r	0·596	1·3r	0·712	1·1r	0·761	1·1r	0·829	r	0·894	0·9r	0·981	0·7r	2·253
2r*	0·321	1·6r	0·571	1·4r	0·688	1·2r	0·752	1·2r	0·814	1·1r	0·897	1·1r	0·988	0·8r	2·268
2·2r	0·295	1·7r	0·545	1·5r	0·660	1·3r	0·732	1·3r	0·788	1·2r	0·865	1·2r	0·959	0·9r†	2·203
2·5r†	0·252	1·8r	0·520	1·6r	0·631	1·4r	0·705	1·4r	0·757	1·3r	0·832	1·3r	0·919	r	2·100
4r	0·143	2r	0·472	2r	0·516	1·5r	0·676	1·5r	0·724	1·4r†	0·805	1·4r	0·879	1·1r	1·988
10r	0·032	10r	0·044	10r	0·047	1·6r	0·645	1·6r	0·690	1·5r	0·768	1·5r	0·836	10r	0·092
20r	0·009	20r	0·012	20r	0·013	10r	0·048	10r	0·050	10r	0·052	10r	0·056	20r	0·026

$f' = \frac{n}{(r+x)^2} - \frac{m}{x^2}$. The values of f' are in terms of $\frac{m}{r^2}$. The * indicates the value Oa (fig. 4, p. 339) of x, for the zero of effective action of the molecules. The sign † indicates the value Ob of x for the maximum of effective attraction of the molecules.

It appears, therefore, that substances for which the ratio $\frac{n}{m}$ is near the value 6·9, should be highly elastic, since their molecular envelopes, and therefore the mutual effective action of the molecules, are but slightly affected by considerable changes in the distance between the molecules.

We are accordingly not only able to see in what elasticity essentially consists, but are enabled to assign to elastic substances their rank on the scale of effective molecular action. It should be added, that a high degree of elasticity is also theoretically possible for ratios $\frac{n}{m}$ materially greater than 6·9, provided the molecules are in the primary condition noticed on p. 441; and also for ratios less than 6·9, provided the molecules are in the secondary condition. Liquids, and solids of feeble tenacity, less than that of india-rubber, may be elastic from the latter physical characteristics. Iron is the only substance whose elasticity is to be attributed to the former characteristics. Of all simple substances, iron has the greatest tenacity; its molecules should therefore have the maximum value of $\frac{n}{m}$.

Inelastic substances, so called, must either be those for which the ratio $\frac{n}{m}$ is greater than 6·9, and which are in the secondary molecular condition, or those for which the same ratio is less than 6·9, and are at the same time in the primary condition. In both of these cases the molecular envelopes will either expand or contract when the distance between them is altered,

and the changes which the envelopes undergo will be attended with a diminution of the molecular actions that are opposed to the force of distortion.

Since reaching this conclusion, with regard to the physical cause of imperfect elasticity, and the precise molecular state of inelastic substances, I have met with a striking confirmation of it in the results of the recent experiments of Dr. Warburg on heat developed by sound. On referring to the table on page 444, it will be observed that for all substances for which the value of $\frac{n}{m}$ is greater than 6·9 (that is, for all the harder and more tenacious substances), the maximum attraction between their molecular envelopes occurs at distances greater than that of quiescence, *Oa*, and that in consequence the diminution of this attraction will be greater for small diminutions of the distance between the molecules than the increase of the same for small increments of the distance. Now a diminution of this attraction will be attended with a contraction of the molecular envelopes and a consequent evolution of heat, while an augmentation of the attraction will be attended with an expansion of the envelopes and a consequent absorption of heat-pulses from without. Since the vibrating body is not perfectly elastic, each momentary expansion will be succeeded by a small residual expansion, and each contraction by a small residual contraction; but since, as we have just seen, in each vibration the contraction will exceed the expansion, the amount of the residual contraction should exceed that of the residual expansion. The result, after any number of vibrations, should then be that there will be a permanent contraction of the molecular envelopes, and therefore a certain amount of heat given out. The gradual subsidence of the vibrations, after the inciting cause has ceased to act, results from the process of contraction of the envelopes, attendant upon each vibration, and the consequent evolution of heat-energy.

India-rubber must belong to that class of substances for which the ratio $\frac{n}{m}$ is less than 6·9, for the heat given out by it when it is stretched, shows that its envelopes must contract when the molecules recede from each other (p. 443). Still as it has a high degree of elasticity, its ratio $\frac{n}{m}$ cannot be very much below 6·9. Again, the fact that heat applied to india-rubber induces a contractile action, shows that its molecules are in the primary condition. These conclusions with regard to the molecular condition of india-rubber, are confirmed by its great extensibility; for as when it is stretched the molecular envelopes contract, and their attractive action diminishes in conse-

quence (p. 442), the ratio $\frac{n}{m}$ will decrease, the curve of molecular action (fig. 4) become depressed, and the distances *Oa* and *Ob* increase. The effective attraction between the molecules that puts itself in equilibrium with the stretching force, as this increases, must then obtain at a distance that augments with *Oa*, as well as in the ordinary way. Its moderate tenacity also assigns to it a comparatively low value of the ratio $\frac{n}{m}$.

The explanation here given of the peculiar properties of india-rubber is strikingly sustained by the results of recent experiments by Prof. E. Villari, published in the Philosophical Magazine (Feb., 1872). He finds that while india-rubber gives out heat on being stretched, it also loses sensible heat on suffering contraction, and the loss in the second case is less than the increase in the first. Now we have seen that according to the position assigned to india-rubber on the molecular scale, its molecular envelopes will contract when the rubber is stretched, and heat consequently be given out; a contraction of the rubber should, of course, have the opposite effect on the envelopes, and heat therefore be absorbed from without. Also, as it is not perfectly elastic, the envelopes contracted by the stretching should not expand to their original dimensions when the force is withdrawn, and hence the fall of temperature during the contraction of the rubber should be less than the rise during the stretching. In fact that it was imperfectly elastic, or did not recover itself after the stretching weight was removed, was directly established by the experiments of Prof. Villari.

12. The principle of the varying physical condition and mechanical action of molecules with varying circumstances (p. 442) also appears to be the originating cause of crystalization and solidification in general, chemical combinations, and in fact all those classes of phenomena which have hitherto been ascribed by most physicists to an inherent polarity of atoms. According to this principle, if upon any side of a primitive molecule the amount of heat received varies, or the attractive action exerted by a contiguous molecule upon its envelope varies, this envelope, at the point considered, will either collapse or expand, and in consequence the effective action exerted by the molecule upon the contiguous one, on the side supposed, will either vary in its intensity or its character. Let us see, in the light of this general conception, how *chemical attraction* may spring up. Two primitive molecules of different substances, when brought into contiguity, will at first come under the operation of their mutual exterior repulson (p. 839), and it is plain that unless this repulsive action be in some way changed into an attractive one, no union of the two molecules can take

place. Now we have seen that contiguous molecular envelopes attract each other; and that the molecules at the surface of bodies, and of gases are, in all probability, in that "primary condition" in which any expansion of an envelope enhances its attractive action. The tendency of the mutual actions of the two molecules supposed, is, therefore, to augment the range of the effective attraction of each (that is, to increase the distance *Oc*, fig. 4), and diminish the exterior repulsion. It is conceivable that the relations of the two molecules, and favoring thermal or other circumstances, may be such that the range *Oc* of the effective attraction may be caused to extend beyond the distance that separates the molecules, and so their union supervene under the operation of this attraction. But it is to be observed that the attractive action exerted by each molecule on the envelope of the other induces an excess of electric ether, or a *positive electric polarity* on the contiguous sides of the two molecules, and so originates an electric repulsion of each envelope for the other, and each molecule for the other. In the instance of two similar molecules these positive polarities should be of equal intensity, and such electric repulsion of necessity be in operation, to a certain extent; but if the molecules are dissimilar the induced polarity of the one may predominate over that of the other sufficiently to superinduce by its action a deficiency of electric ether, or a *negative polarity*, on the contiguous side of the other, and so an *electric attraction* be developed. If this should suffice to bring them within the range, *Oc*, of their natural effective attraction, their union will take place under the operation of this attraction. That this result may be brought about it is necessary that the molecules should have certain special relations to each other; and it is these natural relations that constitute what is called chemical affinity.

These relations are liable to modification, by heat, disturbances of electric equilibrium, and other causes that may tend to disturb the molecular envelopes. Thus heat promotes combustion, and oxidation generally; for it tends to expand molecular envelopes, and so, in that "primary condition" which appears to prevail at surfaces of contact, and in the interior of gases, to augment the attraction subsisting between the envelopes, which we have seen to be the originating cause of chemical union. This tendency may prevail over the direct repulsive action of the heat. On the other hand, heat may operate to dissociate molecules, for it is a repulsive energy, and tends directly to separate them; and we have seen (p. 441) that it is apparently only in a few exceptional cases that the interior molecules of a liquid or solid are in the primary condition in which heat tends indirectly to induce an attraction. In fact the same amount of heat which has been developed in the union of two molecules ought to suffice to dissociate them.

It will be seen, in view of what has been stated, that two primitive molecules of the same substance should seldom, if ever, unite unless their envelopes are brought by heat, or a disturbance of electric or mechanical equilibrium, into different conditions of expansion or electric accumulation. In fact, solidification appears in all cases to begin at certain points of the liquid mass, as the result of thermal or other changes, and proceed outward from these points, from molecule to molecule, along certain lines of direction.

(To be concluded.)

ART. LXI.—*On the Structure of the Skull and Limbs in Mosasauroid Reptiles, with descriptions of new Genera and Species;* by O. C. MARSH. With four Plates.

AN examination of the very extensive series of *Pythonomorpha* remains recently acquired by the Yale College Museum, through contributions from the late expeditions to the Rocky Mountains, has enabled the writer to make out several new points in the structure of these reptiles, in addition to those already announced,* and also to correct some errors of previous observers who have written on the subject. These new results, here briefly recorded, will be more fully discussed in a future communication.

1. *Position of the Quadrate bone.* The great importance of the quadrate bone in this group, in affording generic and specific characters, was first recognized by Prof. E. D. Cope, to whom science is so largely indebted for its present knowledge of this most interesting order of reptiles. In his valuable Synopsis of Extinct Batrachia, etc., p. 183, Prof. Cope pointed out the principal features of this bone in the Pythonomorpha, and proposed a number of terms to designate its most characteristic parts, which were well illustrated by figures in different portions of the work, and in some of his more recent publications.† In the position there assigned to the quadrates in the skull, it appeared to the writer, at the time, that Prof. Cope had reversed these bones, placing the right quadrate upon the left side, and *vice versa*, although retaining their true antero-posterior position. A careful examination of the quadrates in several genera of recent lizards, and especially in the genus *Trachydosaurus*, strongly confirmed this view; and its correctness was finally placed beyond a doubt, during the past summer, by Mr. O.

* This Journal, vol. i, p. 44, June, 1871, and vol. iii, p. 290, April, 1872.

† Synopsis, plate XII, and Proceedings American Association of Science, vol. xix, pp. 217 and 220.

Harger, of the Yale exploring party, who discovered a quadrate bone of *Lestosaurus latifrons* Marsh, in place, and firmly united to the suspensorium. Another specimen in the Yale Museum is equally conclusive. The natural position of the quadrate, therefore, in the Pythonomorpha is with the great ala external. This clears up, at once, several difficulties in regard to the motion of the jaws, which could not be satisfactorily explained when the quadrates were reversed. This discovery of its true position necessitates a change of terms used in describing this bone, and those proposed by Prof. Cope may be amended as follows:—The "external angle" may be called the *internal angle;* the "external ridge," the *internal ridge;* and the "distal-external longitudinal ridge" may be termed the *internal longitudinal ridge.*

2. *Discovery of the Stapes.* This element of the cranium, which had not previously been observed in the Pythonomorpha, was first detected by the writer in the skull of a species of *Lestosaurus.* In this specimen the proximal third of the stapes was attached to the exoccipital, lying in place, in the groove on its lower posterior surface. In another specimen of the same genus (*L. felix* Marsh), the entire stapes, apparently, was found adhering to the base of the skull. In each case the bone was a slender rod, nearly round, expanded proximally, and to some extent also at its distal extremity. The natural position of the stapes was evidently in the groove on the postero-inferior face of the suspensorium. Its proximal extremity was probably in the fenestra ovale, and its distal end in the meatal pit of the quadrate.

3. *Discovery of the Columella.* No evidence of the existence of this bone in the skull of any Mosasauroid reptile has hitherto been adduced, and Prof. Cope asserts that it does not exist in the group.* In removing the rock from the remarkably perfect skull of *Lestosaurus felix,* which had the stapes preserved, the writer found a slender cylindrical bone adhering to the basisphenoid, which is evidently the *Columella.* The bone is somewhat compressed throughout, slightly sigmoid, and has both ends moderately expanded. The lower, or larger, extremity has a deep broad groove in the direction of its greatest diameter, apparently for union with the pterygoid. The opposite end is also excavated, probably for an attachment of cartilage.

4. *Quadrato-parietal arch.* Evidence of the existence of this arch was first observed by the writer during the explorations of the Yale party in Kansas in the autumn of 1870, and on the expedition of the following summer its presence was fully proved for the genera *Edestosaurus, Clidastes, Lestosaurus* and

* Synopsis of Extinct Batrachia, etc., p. 176.

Rhinosaurus. This arch, portions of which have recently been observed also by Prof. Cope, is not formed in most of the genera by a posterior extension of the parietal to the suspensorium, as in many recent lizards, but mainly by an intervening bone which is apparently the squamosal. This unites in front by suture with one of the posterior prolongations of the parietal, and at its distal end is joined to a flat uncinate process of the opisthotic, which is sent off forward and inward to meet it.

5. *Discovery of the Malar arch.* The existence of this arch, hitherto unknown in this group, was conclusively demonstrated by the same remarkably perfect cranium of *Lestosaurus felix*, which retained the stapes and columella; and it is also shown in a specimen of *Edestosaurus.* In the former skull, the jugal is a stout bone, somewhat flattened, and bent at an obtuse angle. It unites by suture with an external process of the post-frontal, the joint being strengthened by a short hook at the extremity of the jugal, which fits into a corresponding pit. Its anterior extremity is united with the maxillary. In all the species of this genus in which this bone has been observed there is a pointed tubercle at the posterior external angle. In *Edestosaurus*, the jugal has a less complicated union with the post-frontal, and is throughout a more slender bone. This arch is apparently well developed also in *Rhinosaurus.*

6. *Pterotic bone.* Among other new points brought to light during the present investigation of the cranium of the Pythonomorpha, may be mentioned the discovery, in *Edestosaurus*, of a distinct ossification at the distal end of the suspensorium, which is evidently the element called the *pterotic* by Huxley. It is a small oval bone, which is attached to the opisthotic, and rests on the superior surface of the quadrate. In several of the genera of this group, the cartilaginous wall which extended from the quadrate to the base of the skull was so much ossified that large sheets of this membrane are frequently found preserved, adhering to the quadrate, or the lower part of the skull.

7. *Anterior Limbs.* Until very recently the nature of the limbs of Mosasauroid reptiles was almost unknown, and in our latest and best Manual on the Anatomy of Vertebrates this deficiency is still acknowledged.* The Cretaceous deposits of this country, however, have of late yielded ample material to prove that these limbs were paddles, and in the present paper several new facts in regard to their structure are adduced. Plate X contains an illustration of the right anterior paddle of *Lestosaurus simus* Marsh, which shows at a glance the structure of the scapular arch and the corresponding limb. This unique specimen, with other important parts of the same skeleton, was found, by the writer, with the various bones almost in the exact

* Huxley, Anatomy of Vertebrated Animals, p. 230, 1871.

position given in the plate, the only exception being that a few of the distal phalanges which were somewhat displaced have been restored to their natural position. The carpal bones, which are given as found, were considerably disarranged, and some of the series had probably disappeared. With this exception, the plate admirably represents the natural position of all the bones of the anterior limb in the genus *Lestosaurus*, and this position may be regarded as typical of the entire group.

This specimen clearly establishes the fact, hitherto unknown, that the number of digits in the manus was five, and that the longest digits had six phalanges and the shortest but four. Moreover, that the paddle was expanded as in some of the Cetaceans, and not contracted as in *Ichthyosaurus*, *Plesiosaurus*, and other Enaliosaurs. Another point of interest is, that, in the genus *Lestosaurus*, the coracoid has a deep emargination, as in many recent lizards, a feature not before observed in any Mosasauroid, and probably existing only in a few genera of the order. There is certainly no emargination in the coracoid of *Clidastes*, *Edestosaurus* and *Baptosaurus*, as specimens in the Yale Museum conclusively prove. The larger bones, as well as the phalanges, had their articular faces covered with a thick cap of cartilage. The terminal phalanges were evidently inclosed in the paddle, and not furnished with nails. The entire manus in *Lestosaurus* is remarkable for its large size, and also for its breadth. In *Edestosaurus*, it had an equally powerful development. The humerus was even shorter and stouter, and the whole paddle apparently broader in proportion. In *Rhinosaurus*, the anterior limbs were proportionally much smaller, and more slender.

8. *Posterior Limbs.* The absence of these extremities in the *Pythonomorpha* was considered satisfactorily established, when the discovery of an unusually well-preserved specimen of *Edestosaurus* revealed to the writer the pelvic arch represented on Plate XI.* Equally conclusive evidence of the existence of these limbs in nearly all the other genera was soon after obtained while investigating the subject, and at the present time there can be no reasonable doubt that they are common to the entire order. In general structure, the hinder extremities correspond essentially with the anterior paddles already described, but in most of the known genera they are of smaller size. The pelvic arch, however, presents some peculiar features, and its elements, which are here figured for the first time, deserve a detailed description.

The acetabulum was formed by the coadapted ends of the ilium, ischium and pubis, which contributed nearly equal portions to its articular surfaces. The direction of the cup is out-

* This Journal, vol. i, p. 447, June, 1871.

ward, downward and backward. The ilium, which is usually the longest of the three pelvic bones, has, in *Edestosaurus*, a nearly round shaft, slightly sigmoid, and tapering gradually to its distal end. This is truncated nearly at right angles to the axis of the shaft, and covered with an articular face. There was evidently a cartilaginous union with a vertebra of the sacral region, although there was no true sacrum in any of the group. This vertebra was probably the last without chevrons, as in a specimen of *Lestosaurus*, with the pelvic arch complete, the right ilium was found by the writer adhering to the right diapophysis of this particular vertebra.

The inferior end of the ilium is in *Edestosaurus* much dilated, with a sub-rhombic transverse outline, and three terminal facets, the largest of which forms part of the acetabulum. The direction of the ilium in this genus, and probably in all the other genera, was oblique, the superior end being turned forward, and the shaft nearly on a line with that of the ischium, as shown in Plate XI, fig. 2. In *Lestosaurus* and *Rhinosaurus*, the shaft of the ilium appears to have been more or less compressed, and the articular face at the upper end somewhat oblique. The bone called "ilium" by Prof. Cope, in his description of *Liodon dyspelor*,* is evidently the *ischium*, and *vice versa*, as is clearly shown by several very perfect pelvic arches in the Yale Museum, some of which were found not only with the elements in position, but, what is much more conclusive, actually united. Moreover, a careful comparison of these bones with the corresponding parts of the pelvic arch in recent lizards, as well as in the extinct swimming Saurians, strongly confirms the interpretation here given.

The ischium in *Edestosaurus* (Plates XI–XII) has the acetabular end expanded and thickened, and just below, on the posterior margin, the *tuberositas ischii* is well developed. The shaft is constricted in the middle, and the distal end has a subtriangular articular face for union with its fellow, although Prof. Cope, in the article above quoted, states that "the pubes are the only elements united below." In *Lestosaurus* (Plate XII, fig. 2, b) the ischium is a broad flat bone with a posterior projection on its proximal third. The distal end is expanded, with the anterior angle especially produced. This extremity has an articular face along its fore-and-aft extent, showing clearly that it was united below to the opposite ischium. In the genus *Rhinosaurus*, the ischia were also flattened, and the posterior process well developed. Their distal ends were moderately expanded, and closely united on the median line.

The pubis is longer than the ischium in all the genera investigated. In *Edestosaurus*, its extremities are about the same

* Proceedings American Philosophical Society, Dec., 1871.

size as those of the ischia, but the distal end is more compressed. There is a prominent anterior process just below the articular end, and the usual foramen is present near the anterior margin. The pubis of *Rhinosaurus* has the acetabular end dilated, the shaft straight and slender, and but little expanded. In all the known genera of the group, the pubes are united on the median line below.

The femur in *Edestosaurus* is slightly shorter than the humerus, and much more slender, being scarcely more than one half as wide. It is moderately expanded at its proximal end, and has a distinct trochanter at the postero-internal margin, which is separated from the head by a shallow groove. The distal end is more expanded, and has the outer posterior angle thickened into a stout obtuse tubercle. In *Lestosaurus*, the femur is very small compared with the humerus, and of much more slender proportions. The articular head is small and convex, and broadly oval in outline. The trochanter is an obtuse ridge, with a rounded articular summit. It is situated some distance below the head, on the outer surface of the bone. The shaft is subtriangular in transverse section, and the distal end is expanded and thickened, especially in the middle. The femur, in the genus *Rhinosaurus*, nearly or quite equals the humerus in size, and has its general proportions similar. Both extremities are moderately expanded, the distal one being the largest. The trochanter has a position similar to that in the last genus.

The tibia in *Lestosaurus* is a very short, stout bone, with the shaft nearly round, and the proximal articular face flat, and broadly oval in outline. The distal end is more expanded, with the articular face narrow, and curving upward at the inner angle to meet the fibula. The latter is a broad discoidal bone, much larger than the tibia. In *Rhinosaurus* the tibia and fibula are both flattened, the latter being as usual the broader bone. In all the known genera, the phalanges of the posterior limbs resemble in their general character those of the manus.

In view of the extensive material now available for comparison, it will not be difficult to identify with tolerable certainty the limb-bones of *Mosasaurus* originally figured by Camper and Cuvier, which have so long been a puzzle to anatomists. The bone called "pubis" by Cuvier, in *Ossemens Fossiles* (Fourth Ed., Plate 247, fig. 10), and since regarded by Prof. Cope as a scapula (Synopsis, p. 219), is evidently an ischium. The two represented in figures 9 and 14 of the same plate are apparently both coracoids, and that in figure 15, a scapula. On Plate 248, the specimen in figure 4 appears to be a radius, and that in figure 6, a phalanx. The bone represented in figure 24, which was thought to be a humerus by Camper, and an ulna by Cuvier, is without doubt an ilium.

Number of Cervical Vertebræ. In all the genera examined during the present investigation, the skull was supported on a very short neck, much shorter, in fact, than any species of the group has been supposed to possess. Prof. Huxley, in the work already cited (p. 224), places the *Mosasauria* with the Reptilia having more than nine cervical vertebræ; and Prof. Cope states (Synopsis, p. 218) that in *Clidastes propython* there are ten cervical vertebræ with articulated hypapophyses. In the Yale Museum are numerous series of cervical vertebræ of *Lestosaurus*, all apparently complete, and several of them known to be so, as they were found in position. None of these series have over four vertebræ with articular faces for hypapophyses behind the axis, and following these one, or sometimes two, with a tubercle more or less developed. In *Edestosaurus*, judging from several series of cervicals apparently complete, there were probably but five vertebræ with free hypapophyses, in addition to the atlas and axis, and, posterior to these, two or three with small rugose tubercles. The same number was observed in a specimen of *Rhinosaurus*. It is evident, therefore, that the neck in this group was unusually short, resembling very nearly, among swimming Saurians, that of *Ichthyosaurus*.

New Genera and Species.

In a catalogue recently published, Prof. Cope has given a complete and instructive list of the species of Pythonomorpha now known from the Cretaceous deposits of Kansas.* These species are arranged under various generic names, which do not, in all cases, meet the requirements of our present knowledge of these reptiles, especially in view of the light thrown on the subject by the very large collections made in that region by the two expeditions from Yale College. An attempt is therefore made below to define more closely the generic relations of the groups best represented in the West. The material for a similar definition of some of the rarer forms, as well as those from the Eastern Cretaceous beds, has not yet been brought together.

Lestosaurus,† gen. nov.

United premaxillaries small, forming a very short obtuse muzzle, that extends little if any in front of the premaxillary teeth: posteriorly they contract rapidly into a narrow wedge. Parietal foramen large. Teeth slender, curved and faceted. Palatines flattened, with palatine teeth more or less pleurodont. Quadrate large, with very large posterior hook. Coracoid with deep emargination. Humerus short and broad. Manus much

* Proceedings American Philosophical Society, vol. xii, Dec., 1871.

† Λῃστής, *pirate*, and σαῦρος, *lizard*.

larger than pes. Vertebræ with rudimentary zygosphenal articulation. Cervical vertebræ with articulated hypapophyses six. Chevrons articulated.

Several species with the above generic characters have been referred to *Liodon* and to *Holcodus* by Prof. Cope. From the former they are widely separated by the teeth, which in *Liodon anceps* Owen, the type species, are compressed, and smooth, as the name implies. The *Holcodus* of Gibbes was based on teeth of *Hyposaurus*, and a single dental crown, which indeed somewhat resembles the teeth of *Lestosaurus* in surface characters, but evidently indicates a different type, as an examination of the original specimen clearly shows. In form, it corresponds essentially to the teeth of *Mosasaurus*, rather than to the slender, pointed, and curved teeth of the present genus, and it approaches more nearly those of *Mosasaurus Copeanus* Marsh, from New Jersey, although there is good evidence to show that the latter species is quite distinct generically from *Lestosaurus*. There is, moreover, no satisfactory proof that the typical species of either *Holcodus* or *Liodon* possesses any of the more important characters adduced for *Lestosaurus*, and there is considerable probability against it. It was certainly very proper to place provisionally in those genera allied species based on fragmentary remains, but to refer to them whole groups with well-marked and clearly established characters, without any conclusive evidence of identity, is to retard rather than to advance science. From *Baptosaurus*, which in some respects appears to be a near ally, the genus *Lestosaurus* may be distinguished by the articular hypapophyses, and emarginate coracoid. It is widely separated, also, from *Mosasaurus*, *Platecarpus*, *Clidastes*, and *Edestosaurus*, by the articular chevrons, as well as by other marked characters.

Lestosaurus simus, sp. nov.

This species is established on the complete anterior portion of a skeleton, including skull, paddles and vertebræ, of one individual, and portions of several others which fully supplement the parts wanting in the first specimen. This was found not only in perfect preservation, but with nearly every bone in its natural position, so that the characters of all were readily interpreted. The right paddle with its corresponding half of the scapular arch is so well represented in Plate X, that this part of the skeleton needs little or no description beyond that already given. The plate was made directly from a photograph of the bones themselves, placed almost exactly as they were found by the writer, in the yellow shale of Western Kansas, in July last. A sketch of the paddle was taken before it was removed from the rock, and every bone numbered, so there

can be no doubt that the illustration given truly represents the natural position of the entire limb, and of its various elements. In Plate XII, fig. 2, the right half of the pelvic arch and femur of another individual of this species is represented, although without placing the bones together in position, except merely to indicate their mutual relations.

The skull in this species is of moderate length, the snout very short and depressed. The premaxillary suture is oblique and quite steep in front, and the anterior nareal expanse is opposite the third maxillary tooth. There are eleven teeth in the maxillary, and thirteen in the mandible. The suspensoria are much depressed, the transverse exceeding the vertical diameter. The basisphenoid is grooved on the median line below, at the junction of the posterior processes. The teeth have their external faces faceted, and marked with irregular striæ, and the inner side strongly striate. The dermal scutes preserved are smooth, and imbricate in arrangement.

The quadrate is large, with a stout elongated hook. The internal angle is nearly a right angle. The distal articular face is prominently convex, with its anterior margin but slightly inflected. There is a large tubercle on the inner margin of the hook opposite the meatal pit, but no articular button. The cervical and dorsal vertebræ have transverse broadly oval articular faces, slightly emarginated above for the neural canal. The articular faces for attachment of the free hypapophyses are sub-trilateral in outline, the smallest angle being in front. The rudimentary zygosphenal articulation is well marked.

Measurements.

Distance from end of snout to premaxillary suture,	34· mm.
Depth of maxillary at anterior nareal expanse,	39·
Length of alveolar portion of dentary,	275·
Width of basioccipital on condyle,	55·
Depth of basioccipital,	28·
Length of quadrate,	93·
Greatest diameter of distal articular face,	47·
Least diameter,	24·
Length of posterior hook,	63·
Length of axis, with odontoid process,	98·
Length of axis alone,	66·
Vertical diameter of articular ball of axis,	27·
Transverse diameter,	36·
Length of centrum of first dorsal vertebra,	58·
Vertical diameter of ball,	33·
Transverse diameter,	48·
Length of humerus,	141·
Greatest diameter at proximal end,	95·
Greatest diameter at distal end,	131·
Length of radius,	99·

Length of ulna,	104· mm.
Length of ilium,	153·
Length of ischium,	138·
Length of pubis,	175·
Length of femur,	116·
Length of tibia,	56·
Greatest diameter of proximal end,	40·
Least diameter,	33·

This species may be distinguished from *Liodon curtirostris* Cope, perhaps its nearest known ally, but a smaller species, by the number of teeth in the maxillary, which are eleven instead of ten; by the more anterior nareal expanse; and by the supra-occipital keel, which is inclined obliquely forward. The two latter characters separate it also from *Holcodus coryphæus* Cope, from which it differs likewise in its large quadrate. From the other allied species, the description given above will readily separate it.

The remains of this species here described were found last summer by Mr. F. Mead, Jr., of the Yale College party, and the writer, in the upper Cretaceous shale, near the Smoky Hill River, in Western Kansas.

Lestosaurus felix, sp. nov.

This well-marked species is considerably smaller than the one just described. It is represented in the Yale Museum by the specimen, already mentioned, with the skull and numerous vertebræ so remarkably well preserved; and by portions of several other skeletons. The muzzle in this species appears to have been much less depressed than in the other known species of this genus, although this character may have been increased in the type specimen by pressure. The nareal expanse is opposite the interspace between the second and third teeth behind the intermaxillary suture. The frontal region was narrow, and the entire skull was of rather slender proportions. The basioccipital keel is inclined obliquely backward, projecting beyond the basioccipital condyle. The suspensoria have a greater vertical diameter than in the last species, and the basioccipital has its posterior margin deflected. The basisphenoid is deeply excavated below on the median line in front, and its anterior lateral processes are slightly deflected. The stapes and columella found with this skull have already been described. The teeth are slender, faceted and incurved, with striæ on the inner face. There are eleven in the maxillary, and twelve in the mandible. Adhering to the jugal bone, is a single dermal scute, which is thick, and pitted externally.

Both quadrates are perfect, and the left is represented on Plate XIII, fig. 4. The great ala is nearly in the same plane as

the external margin of the hook, and hence the inner angle is much greater than a right angle. There is a broad, shallow depression on the front face of the ala near the middle, and below this a deep pit on the inner face above the internal angle of the distal end. The anterior margin of the distal articular face is strongly reflected near the middle.

The cervical vertebræ are short, with broad transversely oval faces, faintly emarginated for the neural canal. The axis has a short spine, much elongated fore and aft, and with caps of cartilage at its anterior and posterior angles, connected by an obtuse ridge. The hypapophysis of the axis stands on the middle of the centrum, and the articular faces for these processes are nearly round, and rest on a prominent ridge, as in *Edestosaurus*, mainly produced by the deep excavation of the infero-lateral surfaces of the centra. The dorsal vertebræ have neural spines much extended antero-posteriorly, and abruptly truncated.

Measurements.

	mm.
Depth of maxillary at anterior nareal expanse,	33·
Width of frontals at posterior margin,	115·
Width in front of orbit,	73·
Distance from center of occipital condyle to end of suspensorium,	90·
Expanse of suspensoria,	170·
Length of stapes,	61·
Length of columella,	51·
Length of quadrate,	81·
Transverse diameter of distal articulation,	39·
Antero-posterior diameter,	20·
Length of posterior hook,	54·
Length of axis without odontoid process,	48·
Vertical diameter of ball,	21·
Transverse diameter,	32·
Length of anterior dorsal vertebra,	60·
Transverse diameter of ball,	38·
Vertical diameter,	32·

The remains on which this species is established were obtained by the Yale party last summer in the upper Cretaceous yellow shale, near the Smoky Hill River in Kansas.

Lestosaurus latifrons, sp. nov.

The present species, which was similar to the preceding in size, is mainly based on portions of two skeletons, one of which contains nearly all the more important portions of the cranium, and vertebral column; and the other consists of numerous vertebræ, with parts of the skull, including a quadrate attached to the suspensorium, to which reference has already been made.

The frontals in this species are broad, especially anterior to the orbits, where there is a lateral expansion. On the median

line near the middle there is a sharp crest. The supra-occipital keel projects obliquely backward, and its posterior edge is sharp. The basisphenoid has the anterior lateral processes expanded, and strongly decurved, thus showing a marked difference from the last described species. There are eleven maxillary and twelve mandibular teeth, which have unequal facets externally, and irregular striæ on the inner face. The palatines are alate, sigmoid in fore-and-aft outline, with the pointed anterior ends converging. There are ten palatine teeth, all more or less pleurodont, the anterior four being entirely so. The quadrate has an elongated depression on the back of the ala near the middle; and a deep semi-circular excavation under the hook, and behind the meatus. There is also a prominent smooth knob on the inner face, between the meatus and the large rugose knob at the end of the hook. The distal articular face has its anterior margin reflected. Its inner angle is acute, and connected superiorly with a sharp vertical ridge. The internal angle of the proximal end is greater than a right angle, and the hook has no articular button. The cervical vertebræ are small, their articular ends transversely elliptical, with no superior emargination. The articular faces for the hypapophyses are round, and that of the axis meets the anterior margin of the ball. The dorsals are elongated, and slightly excavated above. A rudimentary zygosphene is represented by short processes projecting from bases of anterior zygapophyses. The spine of the axis is keeled behind.

Measurements.

Width of frontals between posterior angles,	115· mm.
Width in front of orbits,	85·
Depth of maxillary at anterior nareal expanse,	33·
Transverse diameter of basi-occipital on condyle,	44·
Vertical diameter,	26·
Length of quadrate,	77·
Length of posterior hook,	52·
Transverse diameter of distal articular face,	40·
Antero-posterior diameter,	20·
Length of axis with odontoid process,	68·

This species may be distinguished from *Liodon curtirostris* Cope, and *Holcodus coryphæus* Cope, by the number of teeth in the jaws, or in the palatines, as well as by other characters mentioned above, which also separate it widely from more distantly related species. The known remains now representing it were found last summer, in the upper Cretaceous shale, by Mr. O. Harger, of the Yale party, Mr. E. S. Lane, guide, and the writer, during our explorations, near the Smoky Hill River, in Western Kansas.

Lestosaurus gracilis, sp. nov.

This species, the smallest of the genus so far as known, differs widely from those already described, both in the skull, quadrate and vertebræ. It is at present represented in the Yale Museum by an only single specimen with characteristic remains, and probably by several others with the less important parts preserved. A marked feature in the skull of this species is the superior surface of the parietals, which is small and subtriangular in outline, with the sides incurved. The parietal foramen is nearly round, and larger than in any known species of the genus. The quadrate is likewise very characteristic. The internal angle of the proximal end is much less than a right angle, although the great ala is nearly in the same plane as the outer margin of the hook. This leaves a deep broad notch between the alar process and the internal angle. There is a deep groove below the meatal pit. The distal articular face is convex in its longer direction, but concave antero-posteriorly, owing to a shallow depression which divides the inner third from the outer portion. The lower margin of the ala extends inward nearly horizontally, and is produced into a compressed process, which meets the free end of the hook. The borders of the articular surfaces are strongly striated.

The articular ends of the cervical and dorsal vertebræ are transversely oval, with a distinct excavation on the superior margin. The axis has a low compressed spine, marked with deep striæ. Its anterior margin is oblique and sharp; the articular face for the free hypapophysis is on the middle of the vertebra, and on the other cervicals further back. There is a broad shallow groove around the articular ball in the cervicals and dorsals, and the anterior projection of the diapophyses receives a cap of cartilage from the cup. A rudimentary zygosphene exists in the form of a roof, extending forward over the neural canal, between the anterior zygapophyses, as in several species, but there is no groove between these and the sides of the roof. The zygantral excavations are well marked.

Measurements.

	mm.
Length of parietal on median line,	46·
Width in front,	80·
Antero-posterior diameter of parietal foramen,	11·5
Transverse diameter,	9·
Length of quadrate,	76·
Length of posterior hook,	55·
Transverse diameter of distal articular face,	34·
Antero-posterior diameter,	18·
Length of centrum of axis,	53·
Height of neural spine of axis above floor of neural canal,	41·
Antero-posterior diameter at base,	34·

The type specimen of the present species was discovered last summer by Mr. G. G. Lobdell, Jr., and vertebræ of a second individual by Mr. J. F. Quigley, of the Yale party, in the same formation, in Kansas, as the fossils already described.

The additional species, previously described from the West, that can now be referred with certainty to the genus *Lestosaurus*, are as follows:—*Lestosaurus curtirostris*, = *Liodon curtirostris* Cope, *Lestosaurus ictericus*, = *Holcodus ictericus* Cope, and *Lestosaurus coryphæus*, = *Holcodus coryphæus* Cope.

Rhinosaurus,* gen. nov.

United premaxillaries large, forming anteriorly an elongated cylindrical muzzle, that projects some distance in front of the teeth; posteriorly they contract gradually, and coalesce with a broad nasal element. Mandibles closely in contact at distal ends, and projecting beyond the dental series. Parietal foramen of moderate size. Teeth stout, and more or less compressed and faceted. Palatines narrow, with bases of teeth unequally exposed. Quadrate small, with short posterior hook. Humerus small and slender. Manus and pes of nearly equal size. Caudal extremity comparatively short, with articulated chevrons.

Rhinosaurus micromus, sp. nov.

The present species is established on the greater portion of one skeleton, in good preservation, and fragmentary remains of several others. In the former skeleton, the skull is nearly entire, and shows well the more important characters of the genus. The muzzle is much produced (Plate XIII, fig. 2), and has a rounded obtuse extremity. The premaxillary suture is elongated, and the anterior nareal expanse is opposite the interspace between the fourth and fifth maxillary teeth. The frontals are short, and have a low median crest on the anterior two thirds. There were thirteen teeth in the maxillary, and the same number in the mandible. The teeth are oval at base, compressed above, with their faces marked by facets, and irregular striæ. Both cutting edges are well developed. The mandibles project in front of the teeth, and their inner faces were distally in contact. The articular faces of the joint in the lower jaw are large, and inclined from a vertical. The palatines are narrow in front, rounded above, and have the bases of the teeth unequally exposed, the outer side being protected by a very low parapet of bone. The quadrate is very small, the hook short, and its extremity pointed. The internal angle is very prominent, and continued as a ridge to the antero-internal angle of the distal end. The meatal pit is large, sigmoid in outline, and oblique to the vertical axis of the quadrate. There is a prominent knob below the end of the hook. The distal end has its articular face twisted, and an oblique depression on the inner half.

* From ῥίς, *nose*, and σαῦρος, *lizard*.

The humerus is very small and slender, and moderately constricted in the middle. The deltoid crest is represented by a round articular tubercle, separated from the head by a deep groove. The distal end is somewhat broader than the head, and has, on the inner margin of the ulnar side, an oblique groove, which is much larger than in the other species where it has been observed. The ilium and pubis are slender. The ischium has a well-developed posterior process, and is expanded distally.

The cervical vertebræ have the articular faces but slightly transverse, with a faint superior emargination. The anterior dorsals are subcordate at their extremities, and the posterior dorsals have their articulations still more depressed. The caudals are elevated, and have the chevrons articulated.

Measurements.

Length of dentigerous border of maxillary,	320· mm.
Depth of maxillary at anterior nareal expanse,	44·
Space occupied by twelve anterior teeth in mandible,	295·
Anterior extent of mandible beyond center of first tooth,	32·
Depth of mandible under first tooth,	30·
Extent of seven anterior palatine teeth,	98·5
Transverse diameter of basioccipital on condyle,	54·
Vertical diameter,	25·
Length of basioccipital,	69·
Length of quadrate,	81·
Transverse diameter of distal end,	44·
Antero-posterior diameter,	19·
Length of posterior hook,	43·
Length of humerus,	96·
Greatest diameter of articular head,	44·
Greatest diameter of distal end,	57·
Length of ischium,	106·
Length of axis with odontoid process,	68·
Length of centrum of axis,	44·
Vertical diameter of articular ball,	34·
Transverse diameter,	37·
Length of proximal caudal,	39·
Vertical diameter of ball,	49·
Transverse diameter,	47·

It is only necessary to compare this species with *Liodon crassartus* and *Liodon proriger*, both described by Prof. Cope. From the former it is widely separated by the humerus, which in that species is remarkably short and stout. In the latter, which is three or four times as large as the present species, the cervical vertebræ have vertically ovate articular faces.

The type specimen, on which the above description is based, was found, by the writer, in July last, on the south side of the Smoky Hill River, in Kansas. The geological horizon is the gray shale of the upper Cretaceous.

The remaining known species which clearly belong to the genus *Rhinosaurus* are the following:—*Rhinosaurus proriger*, = *Macrosaurus* (*Liodon*) *proriger* Cope; *Rhinosaurus dyspelor*, = *Liodon dyspelor* Cope; and *Rhinosaurus Mudgei*, = *Liodon* (*Holcodus*) *Mudgei* Cope.

Edestosaurus, Marsh.

This Journal, vol. i, p. 447, June, 1871.

United premaxillaries moderately developed, forming anteriorly a short, obtusely pointed muzzle; and posteriorly tapering gradually. Parietal foramen small. Palatines horizontal in front, but nearly vertical at posterior extremity. Palatine teeth more or less pleurodont. Quadrate small, with internal angle produced. Humerus very short and stout. Manus larger than pes. Femur slender. Vertebræ with complete zygosphenal articulation. Caudal extremity much elongated, and attenuated. Chevrons coössified with centra.

Edestosaurus rex, sp. nov.

This species, one of the largest of the genus at present known, is well represented in the Yale Museum by one very perfect specimen, and the more important portions of several others. The skull is elongated, the frontals converging very regularly in front, and supporting a low median crest, which becomes more prominent anteriorly. The parietal foramen is small and round. The parietals are elongated posteriorly, and the quadrato-parietal arch is proximally lamelliform. The suspensoria are slender. The pterotic bone is oval in transverse outline, and flattened below where it meets the quadrate. The teeth are nearly smooth and compressed, with strong cutting edges. The palatines have fourteen teeth, apparently all with antero-external and posterior cutting edges.

The right side of the pelvic arch and the corresponding femur are represented in Plate XII, fig. 1. The relative position only of the pelvic elements is given. All the specimens have suffered somewhat from pressure, the femur least so. The shaft of the ilium is less sigmoid than in *E. dispar*, and the ischium more expanded distally. The pubis appears to have had a more prominent anterior process. The femur is slender, with its shaft moderately constricted. It is peculiar in having the trochanter at the inner posterior angle. The dermal scutes, like those in *E. dispar*, are smooth externally, and have a complicated imbricate arrangement.

The cervical vertebræ have very broad transversely oval faces, with indication of emargination. The dorsals are elongated, with transverse faces, and distinct superior excavation for neural canal. The articular ends of the anterior caudals are vertically oval.

Measurements.

Width of frontals between posterior angles,	124·	mm.
Distance from parietal foramen to end of suspensorium,	170·	
Length of dentigerous portion of palatine,	164·	
Length of ilium,	124·	
Length of ischium,	102·	
Length of pubis,	108·	
Length of femur,	84·	
Transverse diameter of proximal end,	42·	
Transverse diameter of distal end,	47·	
Length of a posterior cervical vertebra,	44·	
Vertical diameter of ball,	24·	
Transverse diameter,	29·5	
Length of a dorsal vertebra,	62·	
Length of anterior caudal,	38·	
Vertical diameter of ball,	38·	
Transverse diameter,	36·	

This species differs from *Clidastes cineriarum* Cope, in the transverse articular faces of the dorsal vertebræ; from *Edestosaurus tortor* Cope, and *E. dispar* Marsh, in the less number of palatine teeth, and in other characters. *E. stenops* Cope, the only other large species, has the teeth faceted. The known specimens representing the present species were discovered last summer by Mr. G. G. Lobdell, Jr., Mr. G. M. Keasbey, Mr. T. G. Peck, and the writer. The localities were in the upper Cretaceous, on the Smoky Hill River, in Western Kansas.

The remaining species of the genus *Edestosaurus*, that have now been fully identified as such, are the following:—*Edestosaurus dispar* Marsh, the type species, *Edestosaurus velox* Marsh, *Edestosaurus Vymani* Marsh, = *Clidastes Vymani* Marsh, *Edestosaurus tortor* Cope, and *Edestosaurus stenops* Cope.

Yale College, New Haven, Ct., May 15th, 1872.

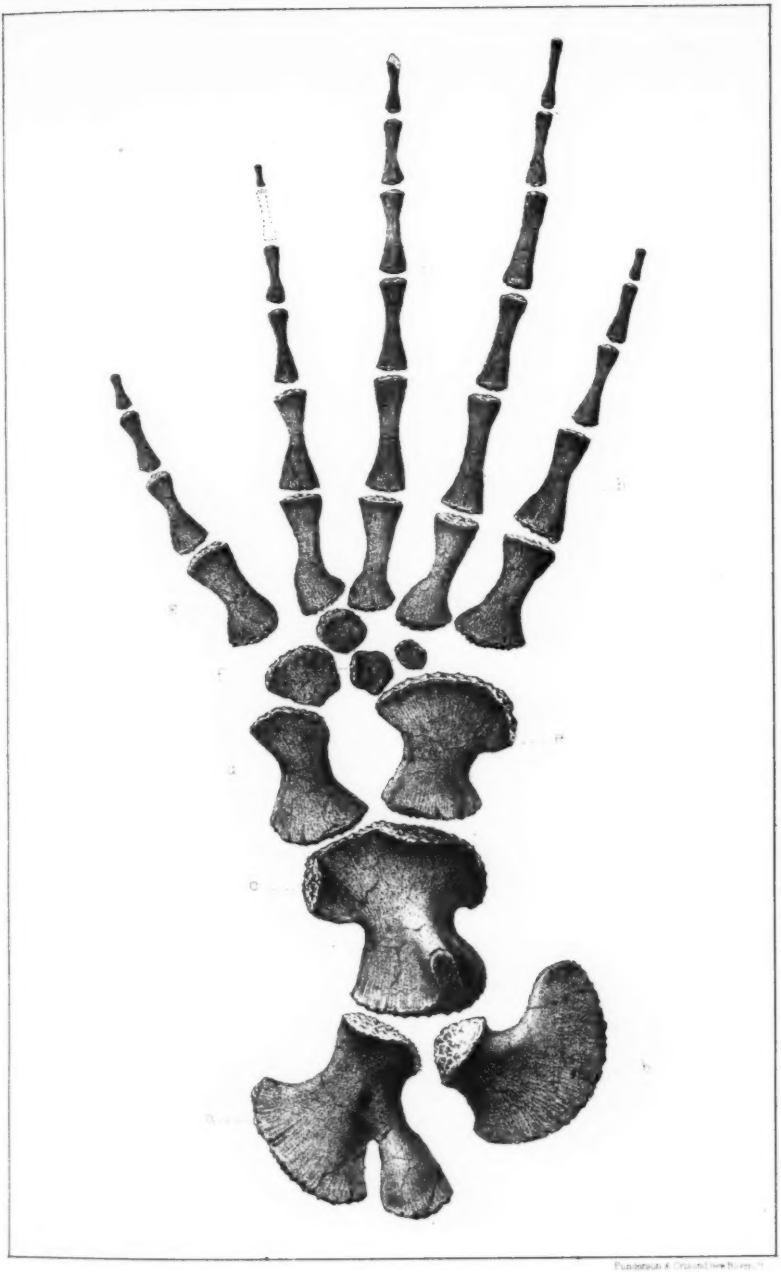
EXPLANATION OF PLATES.

Plate X. Right anterior paddle, with corresponding part of scapular arch of *Lestosaurus simus* (pp. 450 and 455). *a*, coracoid; *b*, scapula; *c*, humerus; *d*, radius; *e*, ulna; *f*, four of the carpal bones; *g*, metacarpal of first digit; *h*, first phalanx of fifth digit. Side view. (½ natural size.)

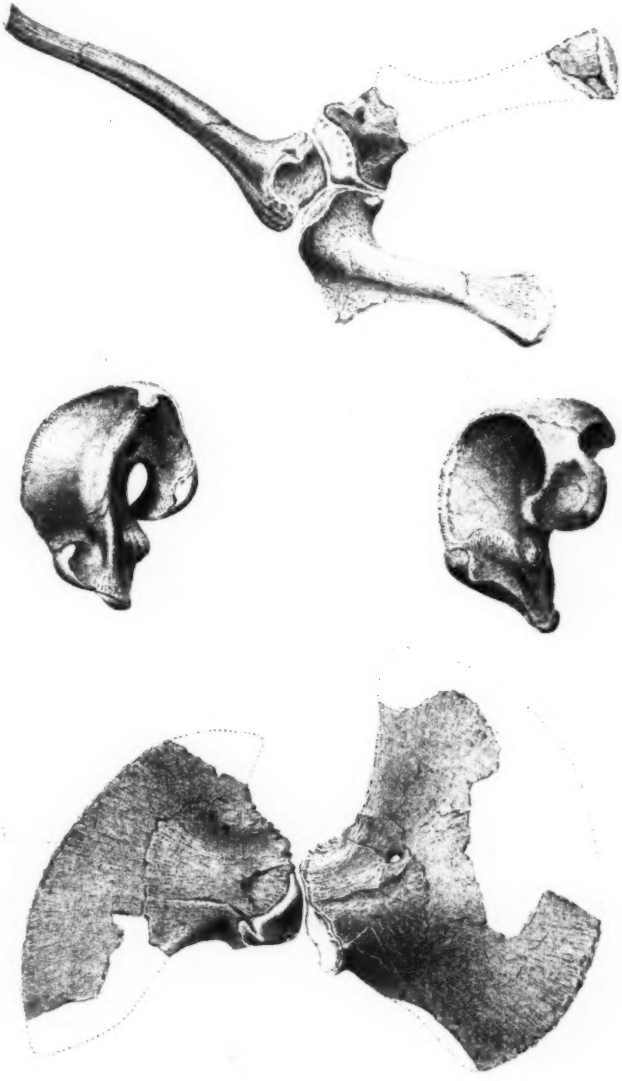
Plate XI. Right half of scapular and pelvic arches, and the quadrates of *Edestosaurus dispar* (p. 451). Figure 1, *a*, coracoid; *b*, scapula. Figure 2. *a*, ilium; *b*, ischium; *c*, pubis. Figure 3, right quadrate, front view. Figure 4, left quadrate, posterior view. (½ natural size.)

Plate XII. Figure 1. Right side of pelvic arch and right femur of *Edestosaurus rex* (p. 463). *a*, ilium; *b*, ischium; *c*, pubis; *d*, femur. Figure 2. Right side of pelvic arch and right femur of *Lestosaurus simus* (p. 453). *a*, ilium; *b*, ischium; *c*, pubis; *d*, femur. Side view. All somewhat flattened by pressure. (½ natural size.)

Plate XIII. Figure 1. Left side of pelvic arch and left femur of *Rhinosaurus*. *a*, ilium; *b*, ischium; *c*, pubis; *d*, femur. Figure 2. Muzzle of *Rhinosaurus micromus*, seen from below. Figure 3. Muzzle of *Lestosaurus latifrons*, inferior view. Figure 4. Left quadrate of *Lestosaurus felix*, anterior view. (½ natural size.)



TESTUDARIUS SIMUS, MARSH. 1/5



1 EDESTOSAURUS REX, MARSH. 2 LESTOSAURUS OTUUS. 1/2

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Reversal of the Spectrum-lines of Metallic Vapors.*—While engaged in photographing the most actinic ray in the magnesium spectrum,—a triple band situated between H and L in the ultra-violet—Cornu observed that on increasing the intensity of the induction-spark, not only was a longer exposure required, but the band became a quintuple one, the two least refrangible rays being doubled. The experiment was repeated twenty-five times, with the same result. The author having obtained this effect in the visible spectrum also, attributes it to a reversal of these doubled lines, produced by an atmosphere of incandescent metallic vapor surrounding the path of the spark. Indeed, by covering one-half the slit of the spectroscope with the metallic spark from a weak coil, and the other with the spark from a powerful coil, it is possible to see the rays superposed, the bright and the reversed line being continuous. For the positive pole, Cornu uses a carbon disk 6 to 8 centimeters in diameter, in which are cavities for the reception of the metal. The negative carbon is lowered until the spark passes, and then raised till the arc is four or five millimeters long. An image of this spark is formed on the slit by means of a lens, the spectrum, in the case of magnesium, showing the triple green ray *b* with great sharpness. On lowering now the upper carbon, the bands widen, become ill-defined, and soon a fine black line appears on the least refrangible of them. If the lowering of the carbon be continued, the second, and at last the third, are reversed also. In this way the author has succeeded in reversing rays in the spectra of sodium, thallium, lead, silver, aluminum, magnesium, cadmium, zinc and copper; the facility of reversal being in the order given. The result was also obtained with sodium and lithium chlorides. Applying this discovery to the sun, the author concludes: (1) that an exceedingly thin stratum of vapor suffices for the reversal; one, the thickness of which could not possibly be seen from the earth; and (2) that it is by no means necessary to suppose a continuous atmosphere, even of this thinness, around the sun; the absorption may be purely local, produced spontaneously by exterior cooling around each incandescent point.—*C. R.*, lxxiii, 332, July, 1871. G. F. B.

2. *A new and powerful Thermo-Battery.*—In this battery, invented by Noë of Vienna, the negative metal is an alloy like German silver, in the form of a wire; the positive, also a secret alloy, is in cylinders, cast round the wire. The wire is protected from the flame by a copper cylinder, insulated from the positive metal by a piece of mica. One of these elements equals in electromotive power 1·24 to 1·36 Jacobi-Siemens' units; therefore 9 to 10 Noë's elements equal one Daniell cell, and 20, one of Bunsen's. A battery of 72 elements, when arranged for intensity, decompo-

ses water rapidly; in two series of 36, puts in complete action a moderate sized Ruhmkorff coil; and in four series of 18, produces powerful electro-magnets.—*Pogg. Ann.*, cxliii, 113. G. F. B.

3. *Anomalous Production of Ozone;* by HENRY H. CROFT, Professor of Chemistry, University College, Toronto (Canadian Journal, vol. xiii, No. 3). About six years ago, when evaporating some syrupy iodic acid, prepared according to Millon's process, over sulphuric acid, I noticed that when the acid began to crystallize, the air in the jar (covering the drying dish) had a strong smell of ozone, or active oxygen. A couple of years afterward, on again making iodic acid, this observation recurred to my mind, and I carefully tested the air in the jar during the evaporation; no trace of ozone could be detected until the acid began to crystallize, when the smell of ozone became immediately perceptible, and all the usual tests for that body succeeded perfectly.

During the last month I have had occasion to convert two ounces of iodine into iodic acid, and exactly the same result has been observed.

The acid usually solidifies to opaque verrucose masses; but on this occasion, the crystals formed were clear and brilliant. The solution had in this, as in all the former cases, been boiled down to thin syrup, so that no trace of chlorine, or nitric acid, could possibly have remained to act on the ozone paper. The air in the jar was tested from day to day, both by the smell, and the action of iodized starch paper. Even when a few crystals began to form no change was noticed, but when the crystallization set in fully the evolution of ozone was most remarkable, the strong smell being quite characteristic, entirely different from that of chlorine or nitric acid.

I am quite unable to account for this ozonification of the air (or oxygen) over crystallizing iodic acid. My friend, Mr. Sterry Hunt, has suggested that it may arise from a partial deoxidation similar to that which produces ozone when hypermanganates are decomposed, as observed by him and other chemists. As the crystallizing acid remains perfectly white, either opaque or transparent, and as the lower oxides of iodine are of a yellow, or even brown color, according to Millon, I cannot accept this explanation, and even if it were true, the phenomenon would be equally unintelligible—a reduction taking place during crystallization. I can offer no explanation of the *simple fact* that air over crystallizing pure iodic acid, becomes ozonized, but I think that the observation seems to offer a wide field for further experiments, which I have unfortunately not the time to carry out.

II. GEOLOGY AND NATURAL HISTORY.

1. ***Remarks on the Taconic Controversy;*** by E. BILLINGS, (From the Canadian Naturalist, vol. vi, No. 3.)—It frequently happens that a science, such for instance as that of geology, possesses a sort of an aristocracy, consisting of the most talented, learned, active and influential of its devotees. The views of

this body of men on any difficult problem that may present itself are usually regarded as conclusive, and are quietly adopted by the less distinguished members. Indeed, the opinion of any one of these latter would be scarcely listened to, provided it should happen to be contrary to the established creed of the dominant party. As a general rule, the leading men are right, and yet it will sometimes happen that they are wrong. One of the most remarkable instances on record is that of the great question in American geology, relating to the age of the rocks which Dr. Emmons called "The Taconic System." Upon this question nearly all of the leading geologists of North America arranged themselves upon one side, and, as it turned out after more than twenty years discussion, *on the wrong side.* Although they were wrong, yet so overwhelming was the weight of their authority, that for nearly a quarter of a century Dr. Emmons stood almost alone. He had a few followers, but they were not men who had made themselves sufficiently conspicuous and influential to contend successfully against an opinion that was supported by all the great geologists of the continent in one compact body. In consequence of this powerful opposition, the Taconic theory gradually sank so low in reputation, that it was at length considered to be scarcely worthy of the notice of a scientific man.

During the last thirteen years, a great revolution of opinion has occurred with regard to the views of Dr. Emmons. Although not entirely adopted, they are now considered to be, in a general way, well founded. The opposite theory, that all of those rocks which he placed in the Taconic system are above the Potsdam sandstone, instead of below it, as he maintained, is completely exploded. It is at this moment dead, more so than was the Taconic theory in 1859, the year in which the subject was reopened. As I understand it at present, some of the Taconic rocks are certainly more ancient than the Potsdam, others may be of the same age, and perhaps some of them more recent. The details are not yet worked out, and judging from the manner in which the strata are folded, broken up and thrown out of their original position by almost every kind of geological disarrangement, I venture to say that no man, at present living, will ever see a perfect map of the Taconic region.

The theory that the Taconic rocks belonged to the Hudson river group, was an enormous error, that originated in the Geological Survey of New York, and thence found its way into the Canadian Survey. No doubt the mistake was due, in the first instance, to the extraordinary arrangement of the rocks, the more ancient strata being elevated and often shoved over the more recent. Thus, without the aid of paleontology, it was impossible to assert positively that they were not, what they appeared to be, of the age of the Hudson river formation. The attitude of the strata, together with their numerous disturbances, might be explained physically, so as to meet either theory. If, for instance, the trilobites of Vermont and Point Levis had turned out to be of

the age of the fauna of the Hudson river group, the rocks would be to this day called Hudson river. There is no apparent physical arrangement to contradict this view, but rather to support it. I do not consider that originally either the physical geologists, or the paleontologists, were much to blame. With regard to the first, when a geologist finds one rock overlying another, he is obliged to accept that as the natural arrangement. Then as to the fossils, with all our increased knowledge, I doubt that any good paleontologist of the present day would feel himself justified in deciding against physical appearances, on the few imperfect specimens figured in 1847, on pl. 67, Pal. N. Y., vol. i. Be this as it may, the object of this note is to show that while the error originated in New York, it was corrected by the Geological Survey of Canada. Dr. Hunt, in his published Address to the American Association in August last, indirectly associates Prof. Hall with me in the rectification of the mistake, whereas neither Prof. Hall nor Dr. Hunt contributed any aid whatever, but, on the contrary, opposed the change that has been made to the utmost.

[These remarks are followed by a history of the observations on the Vermont trilobites, and on the determination of the age of the Black Slate and Red Sandrock of Vermont, substantiating Mr. Billings' claims to having first ascertained the primordial character of the fossils and rocks.—Eds.]

2. *On the True Taconic;* by James D. Dana.—The following, with the exception of some sentences since added, is from a friendly letter to Mr. Billings, addressed to him by the writer on receiving a copy of the paper from which the preceding article is extracted.

You see by the enclosed* that we differ about the Taconic. And yet we do not differ materially. For, viewing the Taconic as you do—the system developed by Professor Emmons through successive interpolations, year after year—you are essentially right, But if you will take his final Geological Report, of 1842, and there see what the Taconic system is as first fully announced, you will find that I am right too. In that report the system is based on a section, fifteen miles long, made across the Taconic range through Williamstown and Graylock to North Adams on the east, and to Petersburg or Berlin (places now on the Harlem railroad) on the west.† It was worked out in that part of Berkshire Co. after

* A copy of a brief article from the May number of the American Naturalist.

† Professor Emmons opens the subject of the "Taconic System" in his final Report (1842) by saying that it extends north through Vermont to Quebec, and south into Connecticut; but the only rocks he describes as the rocks of the system are those of Berkshire County, Massachusetts, and their continuation westward into New York. These are the typical rocks on which the system was founded. On plate xi four figures representing sections across this particular region are given. The only Vermont observations are contained in the only other section on the same plate representing a section from Lake Champlain to Richmond, Vt., through Charlotte. No description of the rocks of this section is to be found in the text of the volume.

In figure 4 of plate xi representing a section through Graylock, the "Taconic slate" stops just west of Berlin, Rensselaer county, New York, the slates on the west

years of residence there; and it was named from the Taconic range because the rocks of this range constitute much the larger part of the section. It was pronounced unfossiliferous, and was stated on conjecture, not from ascertained facts, to range from the "Lower Cambrian" to the lower part of the Silurian.

The dip being throughout to the eastward,* Mr. Emmons very reasonably made the beds to the west the older, only suggesting, and this also very reasonably, and no doubt rightly, that faults might have occasioned some repetitions among the rocks. With regard to this point—the relative age of the beds of the Taconic—he says, in the report of 1842, on p. 145,—after giving a section with the dips to the eastward,—that the view which he adopts is, contrary to that of others, as far removed from complexity as possible, namely that the dip is an indication of age and superposition. Again, on page 147, after having spoken of the three limestones and discussed the question whether they might not be repetitions of the same formation, he decides this question adversely as regards the western bed, and says: "There seems to be no valid reason against the opinion that the most western belt of limestone is, after all, the oldest of the Taconic limestones. All being destitute of fossils, we must judge of age by their relative position, or by superposition; and so long as the most western belt is the inferior limestone, I can see no necessity in the case to suppose a series of complicated changes in order to make it coincide with our conjectures." Accordingly he makes the Stockbridge or North Adams limestone, the most eastern rock in his section, the most recent. He concludes his chapter on the Taconic by the statement that "the Taconic rocks appear to be equivalent to the Lower Cambrian, and are alone entitled to the consideration of belonging to this system, the upper portion being the lower part of the Silurian system:" which obviously means that the slates of the Taconic range, with the western limestone (before called the oldest of the limestones), were true Taconic, while the upper portion, that is, the Hoosic Mountain rocks (see section, p. 159), or else the North Adams or eastern limestone, with or without the quartzite, was, or might be, the lower part of the Silurian system.

But during the year following the publication of the Geological Report of 1842, Prof. Emmons met with a new discovery, and in consequence made most desperate blundering in American geology. He found a "Black Slate" at Bald Mountain, in Columbia Co., N. Y. (west of Berkshire), to contain fossils. As the locality lay to the *west* of the Taconic, it seemed to prove, on the

being put down as "Hudson river shales," and in figs. 2 and 3 the boundary is near Petersburg, north of Berlin, and, on page 138 of the volume, the distinction of the Taconic from the Hudson river shales or slates adjoining (or "upper members of the Champlain group") is particularly dwelt upon. The extension of the Taconic to the Hudson river, so as to include the "slates and masses" of the "Champlain group," appears first in Prof. Emmons's Agricultural Report, published in 1843.

* Prof. Emmons says that the strike of the rocks is very uniformly between N. 10° W. and N. 10° E., and the dip throughout easterly, averaging 30° to 35°. The dips he regards as a result of monoclinal uplifts (pp. 141, 142).

principle adopted in 1842, that all his Taconic system, announced before as unfossiliferous, was *newer* than this Black Slate, that is, *newer than a fossiliferous rock.* This, *to his mind*, was impossible; and he was thence led to think out a way by which rocks might dip eastward and still be newer to the westward; and, without a fact, or even an argument, to sustain it, he announced, in his Agricultural Report published in 1843, this as the true order. He thus, by a stroke of his pen, tipped over the Taconic system, and got the Black Slate to the top, with all other Taconic rocks beneath it; and so, in his mind, it ever remained.* This Black Slate, interpolated in 1843, thus brought mischief to the Taconic system and to much American geology. Its introduction was an error, and a source of greater errors, and it has been an occasion of confusion in the science ever since. It soon followed that these black slates, including that of northern Vermont, so far usurped attention as "Taconic" beds, that the determination of their age was regarded as fixing the age of the Taconic system. Thanks to yourself, the science has escaped from part of the entanglement; and an appreciation of the fact that *the addition of the Black Slates to the system was an error at the start*, will liberate the science from the rest of it.

The quartzite was not put at the bottom of the Taconic in 1842 because, in the Williamstown section, the only quartzite, that of Stone Hill in Williamstown, occurs toward the middle of the section, between Graylock (the highest summit of western Massachusetts) and the Taconic ridge, and the order of superposition seemed therefore to be against it. [The "Oak Hill" quartzite, which has a corresponding position in a second section in the same report (1842), on page 159, has no right there, as it lies wholly to the north of the line of the section.] But in 1843, the quartzite was placed at the bottom of the Taconic series. Hence, in the perfected Taconic of that date and later, the rocks which you have shown to be nearest to the pre-silurian of all the Taconic beds were those which were, by his determination, at the remote ends of the system, the black slate of the top and the quartzite of the bottom; and the former, of *primordial* age, is the only rock of the series which is yet *proved* to be *pre-potsdam.*

The only way for geology to get out of the Taconic perplexity is to go back to Emmons's Report of 1842, where the original basis of the system is presented by its author. The Williamstown section, figured on plate xi of this report, is, as I have said, fifteen miles long; and the quartzite with the associated slate in Stone

* It is probable, from the facts stated by Professor Emmons and others observed by me elsewhere, that the Bald Mountain Black Slates are unconformable to the Taconic rocks. This point I propose soon to investigate. The Taconic slates and the associated limestones I have particularly examined, and have not yet found any evidence that the rocks are newer as you go west, against the order of superposition. The slates of the Taconic range are certainly not newer than those of Graylock; and no fact has yet been brought out that proves the limestone at the western base of the Taconic range to be newer than the Stockbridge limestone.

Hill do not make a thirtieth of its length. The true typical Taconic is therefore not the quartzite portion, but the slates and limestones of the Taconic range, as he has directly declared. In fact, there is some reason for believing that *this quartzite portion* underlies the rest of the Taconic rocks of the section *unconformably*, and hence never was rightly a part of the Taconic series. Whether this last be true or not, the name Taconic belongs only to the era represented by the rocks of Taconic mountain, about which and out of which the system was engendered.

Professor Emmons is deservedly honored for combating the old idea, which prevailed among prominent geologists and paleontologists before and after 1843, that the Taconic slates were slates of the "Hudson river" period. Yet while doing this good work he blundered in everything else, determining nothing correctly as regards the age or order of succession of the rocks of his system; his assumptions after 1842 were so great as to order of stratification and faults, and his way of sweeping distant rocks into his system so unscientific, that his opponents had abundant reason for their doubts. No one knows even now what is the precise age of the slates of Taconic mountain, or, with small exceptions, of the slates over the wide region west to the Hudson (added to the Taconic system by him in 1843), although Logan's view that these rocks belong to the Quebec group is that which appears to be nearest the truth; and no one has sufficient grounds yet for asserting that the "Hudson river beds" (those above the Trenton) may not be included among the beds of the Taconic formation overlying the Stockbridge limestone.

3. *The Development of Limulus Polyphemus;* by A. S. PACKARD, Jr., M.D. 48 pp. 4to, with 3 plates. Memoirs Bost. Soc. Nat. Hist. (Printed without date.)—In this memoir, Dr. Packard makes an interesting and very important addition to our knowledge of the embryology of the Crustacea, in tracing the development of the horseshoe, or king-crab, of our coast. The changes from the impregnation of the egg to near the adult stage are fully described and illustrated. The account of the development of Limulus occupies only a part of the memoir, and is followed by discussions of the homologies of the Merostomata and their relation to the Trilobites, the classification of the Branchiopoda (with which Dr. Packard unites the Merostomata and Trilobites), and their geological succession and probable ancestry. Although fully appreciating the value of these investigations as a contribution to embryology, we cannot quite agree with the views of homologies and classification taken by the author.

Dr. Packard regards Limulus and all the Merostomata as zoëæform, homologizing the anterior portion of the body with the cephalothorax of the zoëa stage of Decapods, and the posterior part of the animal, including the spiniform caudal appendage, with the abdomen of the zoëæ; so that in Limulus the thorax would be wanting, or "potential, as far as regards the presence of external segments." Professor Dana, who regards the caudal spine of

Limulus as alone representing the abdomen, long ago stated the objection to this view. He says, in speaking of Limulus,* "It is an objection to viewing this segment [the middle portion which bears the branchial plates] as abdominal, that in no Entomostracan is the abdomen provided with branchial appendages. Moreover, the close relation to the Caligidæ,—the resemblance as regards the general form and subdivision of the shell, supposing the two segments to be cephalothoracic,—and the near resemblance between the foliaceous appendages and the cephalothoracic appendages, in certain Caligi as well as in Apus and the allied, are believed to be good reasons for adopting the opinion which we have here brought forward." Dr. Packard has apparently been led to his conclusions from seeking for a common embryonic prototype of all the Crustacea, but he seems to us to have gone too far when he is obliged to disregard the more direct relations of Limulus with the Entomostraca (to which he as well as Dana refers the Merostomata) in order to compare it with the young of the Decapods. Professor Dana's views are fully sustained by Owen in a recent paper on the anatomy of Limulus read before the Linnean Society of London.†

Dr. Packard makes four orders of Branchiopoda, which he regards as a subclass, as follows: 1st, Cladocera, 2d, Merostomata, including the suborders, Xiphosura and Eurypterida, 3d, Trilobita, and 4th, Phyllopoda. The fact that the Merostomata have "branchial feet comparable to those of the Phyllopoda," does not seem to us sufficient reason for uniting these groups so closely. The office of respiration in Crustacea is performed by such different organs, even in forms acknowledged to be closely allied, that no great taxonomic value can be attached to the presence of those of a peculiar character. Moreover, branchial feet of peculiar structure are found, among the higher crustaceans, in groups differing widely in other characters, as for example, in the Squilloidea and the Anomobranchiate Thalassinidea.

Under the head of geological succession and probable ancestry of the Branchiopoda, a convenient review of what is at present known of the geological distribution of the principal groups of the lower crustaceans is given, and their derivation from Haeckel's "Archicaris"—an hypothetical crustacean prototype—is discussed.

Although we may criticise Dr. Packard's views of homology and taxonomy, we cannot too highly commend the memoir which records his investigations. These investigations, however, seem to throw little light upon the affinities of the Limuloids, for, within a few months, we have had the most diverse views upon the subject from European naturalists, some regarding them, united with the Eurypterida and Trilobites, as one of the primary groups of Crustacea, while others would separate them entirely from the Crustacea and place them near the Arachnida. S. I. S.

4. *Absorption of Water by Leaves under certain circumstances.*—The investigations of Duchartre and others appeared to prove conclusively that leaves absorb neither water with which they

* U. S. Expl. Expd., Crustacea, p. 40.

† Reported in Nature, for Dec. 28, 1871, and Jan. 25, 1872.

are wetted nor vapor from surrounding air. M. Cailletet confirms this fully, so far as respects the foliage of plants established in the soil and supplied with moisture by the roots. But the revival of wilting leaves when sprinkled or enclosed in a moist atmosphere, however ingeniously explained away, always seemed to bear testimony to absorption. And M. Cailletet's experiments go to show, incontestably, that foliage does absorb liquid water (but not watery vapor) when supply by the root fails or is arrested. His experiments were made by introducing a leafy branch into a glass vessel with a double tubulure, filled with water, the increase or diminution of which was accurately and delicately measured by a manometer. A Bromeliaceous epiphyte, which grew under his care for six years, suspended by a fine wire without root, he found, was able to absorb and fix more than a hundredth part of its weight of water upon a short immersion. His note upon the subject was presented to the French Academy Sept. 11, 1871, and is printed in Ann. Sci. Nat., V, xiv, p. 243. A. G.

5. *Change of Habit.—Loranthus macranthus* of New Zealand, parasitic there upon trees of *Rutaceæ* and *Violaceæ*, is deserting these in favor of trees introduced by the European settlers, such as hawthorn, plum, peach, and especially laburnum, which was introduced as lately as 1859. Its flowers are abundantly visited by the European honey-bee. (*Garden*, i, p. 453.) A. G.

6. *Report on Botany read before the Albany Institute, Feb.* 6, 1872, by CHARLES H. PECK, A.M., notices additions to the botany of the State of New York, the herbarium of which is under his charge, gives an interesting account of the New *Handbook of British Fungi;* but omits all mention of the name of the author or publisher (which we will supply); gives illustrations of the importance of insects in the fertilization of blossoms from an economical point of view, and notes the history and mode of growth of the new *Arceuthobium* parasite on black spruces in the northeastern part of his State, of which Mr. Peck was one of the discoverers, and through whom it first came to the knowledge of botanists. He names it *A. pusillum*, which name being accompanied by a detailed account, will take precedence of the earlier printed *A. minutum* of Engelmann in the new edition of Mann's Catalogue, issued in February, and also recorded in the March No. of the American Naturalist. The printing of two names might and should have been avoided. It would have been well to have recorded the name of the other and earlier discoverer of this remarkable parasite, especially as the honor belongs to a lady. But it is duly stated in the Bulletin of the Torrey Club for November, 1871, and December, 1871; also in American Naturalist for March, 1872. Miss Millington of Glen's Falls is the lady who had the good fortune and acuteness to detect the little plant, at two widely separated stations.

The remainder of the paper is occupied with mycological subjects, in which Mr. Peck is a proficient, and especially with the history and nature of the *black knot* of plum and cherry trees, which is so great a pest in the northern part of the country. As

the result of his own assiduous investigations, he concludes that the malady is really due to a particular fungus, the *Sphæria morbosa* of Schweinitz in ultimate development, but in earlier state a *Cladosporium;* that it is not at all the work of insects nor an autonomous malady. The only remedy as yet suggested is the knife. A. G.

7. *Cooke, Handbook of British Fungi, with full Descriptions of all the Species and Illustrations of the Genera.* London: Macmillan & Co., 1871, pp. 981, in two volumes, 12mo.—This is the work mentioned in the preceding article, and the one by which American students are to acquire a knowledge of our own *Fungi* until the wished-for day arrives in which we may have a Mycologia of our own. No better model than this could be asked for. By its aid good progress can be made in the study of our own species; and it will be interesting to know that the occurrence of any British species in this country, so far as yet recorded, is duly mentioned in these volumes. Copious and characteristic woodcuts are intercalated in the letter press, as well as separate plates of *Agarici*, etc. The whole is not only brought up to the latest matured views in mycology, but these views are most clearly and tersely presented. A. G.

8. *Intelligence.*—At the very time in which this welcome aid is supplied to those who would enter upon the study of our *Fungi*, we have to lament the sudden death of our veteran mycologist, the *Rev. Dr. M. A. Curtis*, of Hillsborough, North Carolina. He died on the 10th of April, just before completing the 64th year of his age. A biographical notice will be given later.

Prof. Hugo von Mohl, the prince of vegetable anatomists of our day, was found dead in his bed on the morning of the first of April.

Prof. A. de Bary is transferred from Halle to the University of Strasburg, and Dr. Hermann Count Solms-Laubach is appointed extraordinary Professor of Botany,—a strong botanical professorate for the new German University.

Dr. McNab, late Professor of Botany at the Agricultural College at Cirencester, has been appointed professor at the Royal College of Science and Arts, Dublin, in place of Dr. Dyer, who has taken the professorship at the Royal Horticultural Society, London. A. G.

9. *The Journal of Botany, British and Foreign*, since the death of Dr. Seemann, edited by Dr. Trimen of the British Museum, and Mr. Baker of the Royal Herbarium, Kew, has apparently entered upon a career of assured prosperity. An extremely good portrait of the late editor adorns the February number (and a biography is given in that for January which we have only now received).

Dr. McNab contributes some *Histological Notes;* one of them pointing out the fact that *Cynara Scolymus* (the *Artichoke*) has the woody bundles of the stem scattered through the cellular tissue after the manner of *Nymphæaceæ* and *Cucurbita*, giving it an apparently endogenous character. He also describes certain

elongated thickened cells in Pine-leaves, which resemble bast cells in general character, but are widely separated from the fibro-vascular bundles, and apparently "sub-epidermal."

Dr. Bennett reports from Australia a case of poisoning from the seeds of *Macrozamia spiralis*, and an analysis, which shows that they contain binoxalate of potash as the poisonous element.

Mr. Baker, in the March number, reproduces from the *Refugium* the characters of his new Liliaceous genus *Symea*, with a figure and further remarks.

Rev. E. O'Meara begins an account of *Recent Researches in the Diatomaceæ*, principally German, which promises to be interesting and timely. He rather deprecates, but thinks correct, the proposed change of the name *Diatomaceæ* to *Baccillariaceæ*, on the ground that *Baccillaria* is an older generic name than *Diatoma*. Where does he find any rule requiring that an order should bear the name of its oldest genus?

Dr. Hance contributes a note on *Castanea vulgaris* Lam. (the name he adopts for *C. vesca* L.), as profitably cultivated for its fruit in the very south of China; and adds some remarks about the geographical distribution and systematic extent of the species, which seem to imply that he would include in it even *C. pumila*, our *Chinquapin*.

The other leading articles relate to British Botany; but one of them, viz., *Notes on the British Ramalinas in the Herbarium of the British Museum*, by the Rev. James M. Crombie, is of general interest.

Among the short notes, extracts, etc., Prof. Dickson calls attention to Irmisch's papers in the Linnæa and Botanische Zeitung, showing that in *Delphinium*, *Anemone*, several *Umbelliferæ*, etc., the long petioles of the cotyledons in germination unite into a narrow tube, from the base of which the plumule usually bursts, giving the appearance of a hypocotyledonary bud, and that the case of *Delphinium nudicaule* mentioned in this Journal, vol. ix, is of this sort. The present writer had overlooked Irmisch's papers. A reference to them was promptly given in this Journal.

Dr. Kurz announces "dimorphism" in the Indian species of *Eranthemum*. From his account it is clear that the case is like that of *Ruellia*, so long familiar.

Dr. Carruthers contributes to the February number a Review of the Contributions to Fossil Botany, published in Britain, in 1871, with critical remarks.

Notices of other articles will be given hereafter. A. G.

10. *Fossil Flora of Great Britain.*—With much satisfaction we learn that Dr. Carruthers is editing a re-issue, in monthly parts, of Lindley & Hutton's Fossil Flora, to which he is to add a supplementary volume, to contain exact delineations, by means of wood-cuts and not less than 40 plates, of the discoveries in Fossil Botany since 1837, together with descriptions and a synopsis, which will bring the whole work up to the state of the science at the present day." This will be a most important work, sure to be ably and faithfully done. A. G.

11. *The Garden*, a "Weekly Illustrated Journal of Gardening in all its branches," is of about the size and extent of the Athenæum, i. e., smaller than the Gardeners' Chronicle, but of about the same number of pages, is published in London, and conducted by Mr. Wm. Robinson, who is so well and favorably known in his Parks and Gardens of Paris, his Alpine Flowers, Wild Garden, etc., as well as personally to those who had the pleasure of making his acquaintance during a recent visit he made to this country. The publication began toward the close of the last year, so that it is now in its first volume; No. 17, the number for March 16, extends to p. 388. It covers a somewhat different ground from that of the excellent and long established Gardeners' Chronicle, is more devoted to landscape gardening and ornamental cultivation, and seems admirably adapted to the wants and tastes of gentlemen who are interested in rural affairs. By such we hear it highly spoken of; and we think we do a favor to those of that class who know it not as yet, by calling attention to it. We shall probably have occasion to make some extracts, or at least should do so if we could find room. A. G.

III. Astronomy.

1. Zöllner *on the Nature of Comets.**—Among a number of other matters relating to the history and progress of human knowledge, the volume whose title is given below contains some contributions to the theory of comets, which are so novel and remarkable as to merit more than a passing notice, and we give a brief abstract of the more prominent points of the discussion. As important to the history of the subject, the author has caused to be reprinted the two celebrated memoirs of Olbers and Bessel on comets. These are followed by his own memoir, entitled, "On the Stability of Cosmical Masses and the Physical Constitution of the Comets," in which it is his purpose to explain the observed phenomena by the application of well established principles of physical science, and these only.

Starting from the well known fact that water, mercury, and many other substances, even in the solid state, give off vapor, of a certain amount, though of very low tension, and inferring from the characteristic odors of the metals, that they also, even at very low temperatures, are constantly giving off vapor, though of an amount too small to be recognized by any of the tests yet employed in science, it follows that a mass of matter in space will ultimately surround itself with its own vapor, and the tension of the latter will depend upon the mass of the body, that is, upon its gravitative energy, and the temperature. If the mass of the body is so small that its attractive force is insufficient to give to the enveloping vapor its maximum tension, for the existing tempera-

* Ueber die Natur der Cometen Beiträge zur Geschichte und Theorie der Erkenntniss; von Johann Carl Friedrich Zöllner, Professor an der Universität Leipzig. Mit x Tafeln. Leipzig, Verlag von Wilhelm Englemann. 1872. 8vo. pp. c, 523.

ture, the evolution of vapor will be continuous until the whole mass is converted into it.

Then comes the question whether a mass of gas or vapor under these circumstances would be in a condition of stable equilibrium. The analytical discussion of this point leads to the result that, in empty and unlimited space, a finite mass of gas is in a condition of unstable equilibrium, and must become dissipated by continual expansion and consequent decrease of density. A necessary consequence of this result is that the celestial spaces, at least within the limits of the stellar universe, must be filled with matter in the form of gas, preëminently that of the terrestrial atmosphere.

The author then proceeds to discuss the density of atmospheric air upon the surfaces of the celestial bodies and in space. Assuming for the purposes of calculation, and in accordance with the above-mentioned considerations, that the space occupied by the stellar system is everywhere filled with atmospheric air, and taking the temperature as that of melting ice, he finds that the lower limit of density for a portion of gas in space is $\frac{1}{10^{246}}$ of that of the air at the earth's surface, a value so small that a mass of air which, at its ordinary density upon the earth's surface, would occupy a volume of one cubic decimeter, when reduced to the density expressed by this fraction, would fill a sphere whose radius would not be traversed by a ray of light in less than 10^{98} years. Such a medium could have no appreciable effect, either upon the rays of light or upon the motion of bodies in space. The value becomes still smaller if the temperature of space is taken at $-60°$ C. with Fourier, or at $-142°$ C. with Pouillet.

Any solid body in space must, by virtue of its gravitative energy, condense the gas to form an atmosphere upon its surface, and the density of this gaseous envelope can readily be calculated when the size and mass of the body are known. For the moon the value is found to be $\frac{1}{10^{332}}$ of that of the air at the earth's surface, a vanishing quantity, and one completely in accord with the fact that no trace of a lunar atmosphere has ever been detected. For the larger planets, on the other hand, the value becomes very great, so great in fact, that the high density of their atmospheres must occasion perceptible effects, by absorption, upon the light reflected from them, and the result lends a new interest to the peculiar spectra of Uranus and Neptune, as well as of Jupiter, which appear to exhibit lines resulting from atmospheric influences.

If a fluid mass, a meteoroid for instance, should exist at a distance from the sun or any body capable of radiating heat to it, its temperature would be that of the surrounding space, and, if its mass were not too great, a slow evaporation would convert it after the lapse of sufficient time into a sphere of vapor. Should the fluid mass, on the contrary, approach the sun, the solar heat would occasion a continuous development of vapor on the sun-

ward side of it, until the whole were vaporized in a time incomparably short with reference to the interval necessary in the former case, and the smaller the amount of matter the shorter this time would be. The smaller comets, which often have the appearance of spherical masses of vapor, are examples of bodies of such a nature. Prof. Zöllner thinks there is no improbability of the existence of such fluid masses in space, consisting of water or of liquid hydro-carbons,* and the spectra of some of the nebulæ and smaller comets confirm the idea very strongly.

The peculiarities already mentioned are readily explained by reference to the general properties of fluid substances. The comets, however, offer others which are the result of other causes, namely, their *self-luminosity*, and the formation of a *train*, with a special relation of the latter, in its position and direction, to the sun.

As to the origin of the former of these phenomena, the question arises, under what circumstances can a vaporous or gaseous mass become self-luminous? and only two causes are known through the operation of which this can happen. These are, first, elevation of temperature, as by combustion, and second, electrical excitement. The former of these causes the author sets aside, on account of its insufficiency and the theoretical difficulties and contradictions which it involves. The second, therefore, must be assumed to be the efficient cause, unless recourse is had to unknown agencies, and this the purpose of the investigation excludes. Granting that electricity may be developed by the action of solar heat, if not in the process of evaporation, at least in the mechanical and molecular disturbances resulting from it, we have a cause sufficient to account both for the self-luminosity of the comets and the formation of their trains. It is shown, moreover, by numerous experiments, that the production of electricity by similar processes within the limits of our experience is a well established fact.

The spectrum of the vaporous envelope of a comet illuminated in this manner must necessarily be that produced by the passage of an electrical discharge through vapor identical in substance with a portion at least of the cometic nucleus, from which the envelope is derived. As, according to the supposition, water and liquid hydro-carbons are important constituents of these bodies, the spectra of the comets should be such as belong to the vapors of these substances, and in this manner the resemblance and partial coincidence of the observed cometic spectra with those of gaseous hydro-carbons is explained.

The author next proceeds to consider the formation of the train. The form and direction of this appendage to the comet indicate the action of a repulsive force. Olbers in 1812 had found the existence of a repulsive force necessary to the explanation of the direction and form of the train, and though in his memoir upon the great comet of 1811 he carefully abstains from the expression of a decided opinion upon its nature, he remarks that one can

* See note, p. 479.

scarcely fail to think of something analogous to electrical attraction and repulsion. Bessel also, in his memoir upon Halley's comet, published in 1836, shows a like caution, but clearly recognizes the similarity of the phenomena to those produced by electricity and magnetism, and feels compelled to admit the action of a polar force.* After citing these opinions, and remarking that the phenomena point to an action of the sun at a distance different from the force of gravitation, Prof. Zöllner asserts that the assumption of an electrical action of the sun upon the bodies of the solar system is necessary and sufficient to account for all the essential and characteristic phenomena of the vaporous envelope and the train.

He then discusses the quantitative difference in the effect of gravitative and electrical forces upon ponderable masses at a distance, and shows that, when a body is at the same time under the influence of both these agencies, with an increase of the mass there results a preponderance of gravitation over electricity, and with a sufficient decrease in the mass the contrary. Hence the nuclei of the comets, as masses, are subject to gravitation, while the vapors developed from them, as consisting of very small particles or molecules, yield to the action of the free electricity of the sun. An analytical investigation of the motion of a small sphere under the action of gravitation and atmospheric electricity, based upon Hankel's numerous and very careful researches upon the determination of atmospheric electricity according to an absolute standard (*nach absolutem Masse*), leads to the remarkable result that, supposing the free electricity of the sun to be no greater than that which has repeatedly been observed on the earth's surface, and to be uniformly distributed, it would communicate to a sphere having a diameter of 11 millimeters and a weight of $\frac{1}{100}$ of a milligram, and starting from the sun, by the time it had moved as far away as the mean distance of Mercury, a velocity of 3,027,000 meters, or 408·4 geographical miles per second, or such that in two days it would pass over a space of 70,540,000 geographical miles. The comet of 1680 developed in two days, when near its perihelion, a train of 60,000,000 miles.

* M. Faye assumed, for explanation of the peculiar appearances of a comet's train, a repulsive force as existing between bodies at a high temperature, and as an effect, or one of the modes of action, of heat, a cause which cannot be regarded as confirmed by known facts or by experiment.

Prof. W. A. Norton, in 1859, in discussing the phenomena of Donati's comet, assumed electricity to be the repelling force, and appears to have been the first to enunciate distinctly the adequacy of this force to produce the observed effects, and to give the rationale of its action. He says, "I conceive the telescopic nucleus of a large comet to consist of an atmosphere of aqueous vapor, or of a vaporous and gaseous atmosphere combined, condensed upon an inner nucleus more or less covered with water, or water partly in the condition of ice. In the case of the telescopic comets this central mass is probably altogether wanting. The vaporous atmosphere of the nucleus experiences variations of electrical excitement under the influence of the sun;—after the same manner that the earth's atmosphere is affected by the sun. * * * * It is these electric discharges * * * that, as I conceive, disengage the particles of aqueous vapor, or nebulous matter so-called; and impel them off with a certain velocity." This Journal, May, 1859, p. 100.—A. W. W.

These are magnitudes of the same order, and show that it is sufficient to attribute to the sun electrical energy not greater than that which is observed at the earth's surface, to account satisfactorily for the appearances presented by cometic trains, and that it is quite unnecessary to assume the existence of some otherwise unknown repulsive force.

Furthermore, comets have appeared with trains directed toward the sun, and such a direction is easily explained by the supposition of opposite instead of like electrical characters, which accords perfectly with the phenomena observed in the development of electricity by vapor-streams in the hydro-electric machine, where, as is well known, the sign of the electricity depends upon the presence or absence of various substances in the boiler or the tubes.

The theory acquires an additional interest, and a strong confirmation, from Schiaparelli's remarkable discovery of the identity of the paths of certain comets with great meteor-streams, since the meteoric masses must inevitably be converted into vapor on approaching the sun, even at great distances if composed of liquid matter, but only on a comparatively near approach if solid, with the exhibition of the characteristic appearances of the comets.

The author applies the results of these investigations to various details of the peculiarities observed in different comets, and to the related questions of cosmical physics in their bearing upon the moon's atmosphere, the corona, zodiacal light, polar auroras, and the phosphorescence of the nocturnal sky, and other phenomena. A later portion of the volume contains a lively discussion of Tyndall's theory of comets. A. W. W.

2. *New Planets.*—The planet (119), the discovery of which, by Prof. Watson, on the 4th of April, was announced in the May number of this Journal, was discovered independently, at a later date, April 9th, by Mr. Paul Henry, at Paris.

The planet (120) was discovered by Mr. Borelly, at Marseilles, on the evening of the 10th of April. On the evening of the 11th of April, this planet was also independently discovered by Prof. Peters, at the Litchfield Observatory of Hamilton College. The clouds prevented a second observation until April 16th. The following observations were made by Prof. Peters:

1872 April 11,	14^h m. t.	R. A. $12^h\ 0^m\ 5^s$	Dec. $-4°\ 59'$
" 16,	$13^h\ 37^m\ 29^s$	$11^h\ 56^m\ 52^s{\cdot}42$	$-4°\ 44'\ 39''{\cdot}1$
" 17,	$11^h\ 7^m\ 16^s$	$11^h\ 56^m\ 20^s{\cdot}96$	$-4°\ 42'\ 15''{\cdot}8$
" 19,	$11^h\ 52^m\ 8^s$	$11^h\ 55^m\ 13^s{\cdot}69$	$-4°\ 37'\ 1''{\cdot}6$

3. *Discovery of a new Planet;* by James C. Watson.—I have discovered another planet belonging to the group between Mars and Jupiter. It shines like a star of the eleventh magnitude.

The following are the only complete observations of it, which I have yet made.

Ann Arbor M. T.	(121) α	(121) δ	
1872, May 12, $14^h\ 13^m\ 42^s$	$16^h\ 20^m\ 37^s{\cdot}58$	$-18°\ 53'\ 9''{\cdot}4$	5
13, 11 13 22	16 19 59·35	−18 52 46·2	6
Daily motion,	$\Delta\alpha = -44^s$	$\Delta\delta = +0'26''$	

IV. Miscellaneous Scientific Intelligence.

1. *On the occurrence of Petroleum in the Island of Santo Domingo;* by W. M. Gabb. (Editorial correspondence, dated Sto. Domingo, April 20, 1872).—We must add to the known localities of bituminous products in the West Indies a single locality in the Dominican Republic. This is a spot about three miles north of the town of Azua, on a stream called "el Agua hediondo," or stinking water. The spot reminded me strikingly of the California petroleum springs, not less in the existence of oil, pitch, and gas, than in the usual broken-down steam engine and fragments of artesian well tools lying scattered around. The spring makes its appearance as a stagnant, torpid pool, exuding slowly through a heavy gravel deposit. A very small area in the vicinity is covered by deposits of pitch; for half a mile down the now dry bed of a rain-water stream the gravel or sand, as the case may be, is more or less cemented by an impure pitch, sometimes plastic, oftener hardened to asphaltum. The pools of the spring and neighboring excavations contain a dirty water rendered brown by contact with the oil, and on the surface is a thin pellicle of liquid petroleum, dark brownish-green to reflected light, and a reddish brown by transmitted light. On rubbing a drop in the palm of the hand it does not disappear as readily as the oil of California; and the odor is not so much like kerosene, but rather fetid.

An attempt was made during the "oil excitement" of 1865 or 1866 to bore here. The usual tools were taken to the spot and eventually abandoned. In the piece of pipe yet remaining is a small accumulation of oil, through which bubbles up a gas. It is inodorous and is not inflammable. At the distance of a few yards is a depression where there are several gas jets, and where, over the whole area, there is not a single blade of grass or any other vegetation.

I consider this locality especially interesting, because it is the only spot in the whole Republic of Santo Domingo where bituminous products are found, and because of its resemblance in so many respects to the localities I have seen in California. It also agrees with the springs of Trinidad in its appearance and mode of occurrence. See report of the Colonial Geologists, London, 1860, pp. 134 et seq. See also Schomburgh, Hist. of Barbadoes, pp. 553 and 569.

2. *Terrestrial magnetism, a measure of the sun's rate of rotation;* Ch. Hornstein.—The changes in the three elements of terrestrial magnetism, viz, the declination, inclination, and horizontal intensity, appear to run in a cycle of 26·33 days. In 1870, the periodic change in the declination at Prague was equal to $0'{\cdot}705 \sin (x + 190°20')$, x equaling 0 on January, 1870, and 360° on January, 1871. This oscillation is a little greater at Vienna. The oscillation in the inclination in 1870 was a third that of the declination, and that of the intensity about 24 units in the fourth place of

decimals. The cycle corresponds therefore with the time of the sun's rotation, the mean of which is 26·33 days. The magnetic needle thus affords a new method of determining the period for synodic rotation. By it we arrive at the true period of rotation of 24·55 days, which is almost identical in value with that deduced from the spots of the equatorial solar zone—24·541 days, according to Spörer.—*Acad. Sci. Vienna, from Les Mondes, April* 25.

3. *The Metric System of Weights and Measures;* An address delivered before the convocation of the University of the State of New York, at Albany, August, 1871; by FREDERICK A. P. BARNARD, S.T.D., LL.D., President of Columbia College, New York, 1872. 8vo. pp. 194.—President Barnard's address on the Metric System was delivered in obedience to a resolution of the Board of Trustees of Columbia College, requesting him to attend the convocation of the University of New York, at Albany, in August, 1871, and explain to that body how far the views of the Faculty of Columbia College, in respect to the Metric System of Weights and Measures, are in accordance with those of a committee made to the convocation on that subject the previous year. From this statement it is obvious that the discussion must partake somewhat of a controversial character; but it is managed with excellent taste and fairness in this particular. The singularly illogical positions of the eminent reporter of the former year, adverse to the adoption of the metric system, are controverted without the least acrimony and with a most charming geniality of humor.

But the scientific interest of Dr. Barnard's address is its feature of real and permanent value. Like all his writings this address is characterized by completeness, exactness and clearness of statement. He divides his subject under the following heads, "Origin and Nature of the Metric System; Recent progress of Metiological Reform; Objection to the Metric System considered;" and in a series of Appendices and Notes he adds important data "On the Unification of Moneys; Effect upon existing contracts of a change in the legal weight of coins; The New System of Coinage of the Japanese Empire; On Capacity Measures and the Weight of a given volume of water; On Kater's determination of the weight of a cubic inch of water; On the Legislation of Great Britain and of British India in regard to the Metric System; On the extent to which the Metric System has been adopted." This address must remain a classic in our language for its able and impartial discussion of the important subject of weights and measures, and cannot fail to exercise an important influence in advancing and strengthening the public appreciation of the world-wide importance of this subject, leading, it is to be hoped, at no late day to the adoption of the only system which has any chance of success as a universal standard, viz., the *Metric System.*

B. S.

4. *Die Naturgesetze der Fütterung der landwirthschaftlichen Nützthiere*, von Dr. PHIL. THEODOR VON GOHREN, 637 pp. 8vo., with 36 wood cuts, Leipzig, 1872. C. L. Hirschfeld.—This work,

so far as we have had time to examine it, appears to be an admirable digest of the vast mass of materials which has accumulated —within the last 20 years very rapidly—bearing on the subject of animal nutrition, considered both as a branch of physiological science and as an art. After an introductory chapter on "Matter and Force," the parts of the animal body are described, in respect to their structure and functions; then the Chemistry of the Tissues, Juices and Secretions; and thirdly the Processes of Life and Growth—Respiration, Metamorphosis of Tissues, Digestion and Resorption—are discussed. The titles of the other chapters are Individual Kinds of Cattle Food: the preparation of Fodder and Feeding: The availability (Ausnutzung) of Cattle Food: History of Doctrines of Nutrition: Present State of the Doctrines of Nutrition: The Production of Work: The Production of Fat: The Production of Flesh: The Production of Milk: The Production of Wool: Reproduction and Nutrition: The Practical Farmer and the Doctrines of Feeding. Appendices, Tables, and a copious Index complete the book.

The author, Professor at the Royal Bohemian Agricultural Academy at Liebwerd, gives equal justice to fundamental investigations like those of Pettenkofer and Voit, and to the many empirical trials which have been conducted with such patience and skill at the various experiment stations in Germany and elsewhere. He combines the hitherto too isolated results of physiologists, chemists and agriculturists, of philosophers and practicians, in a manner that cannot fail to be advantageous to all who have occasion to occupy themselves with the subjects of his treatise, whether for elementary or advanced study. The contrast between this masterly work and anything under a similar title which English literature has yet produced, is humiliating to the latter. S. W. J.

5. *Pocket-book of Mechanics and Engineering, containing a memorandum of facts and connection of Practice and Theory;* by JOHN W. NYSTROM, C.E., 11th ed., revised and greatly enlarged with original matter, 512 pp., 12mo. Philadelphia, 1872 (J. B. Lippincott & Co.).—This "Pocket-book" is an exceedingly convenient companion for people of all trades and professions, far more so than is implied in the title. It meets the necessities not only of practical engineers and mechanics in the calculations which their work requires, but, also of all who have anything to do with figures beyond casting up ordinary accounts, and is especially a desirable hand-book for the scientific and even the ordinary traveler. Besides containing the many tables and formulas of use to the engineer and mechanic in all branches of work, it gives others for the use of the barometer in determining heights, tables of logarithms, and of logarithmic and natural sines, tangents, etc.; of squares, cubes, square roots and cube roots for numbers from 1 to 1,600; of the circumference and area of circles for diameters from 1 to 1,000; of the coins, weights and measures of the world; of the flags of nations; of the areas of the continents; of the distances

of places over this and other countries; also an almanac for the 19th century; an astrononical almanac; the deaf and dumb alphabet, etc.

6. *An Elementary Manual of Chemistry*, abridged from Eliot and Storer's Manual, with the coöperation of the authors, by Mr. RIPLEY NICHOLS, Assistant Professor of General Chemistry in the Massachusetts Institute of Technology. 370 pp. New York, 1872, Ivison, Blakeman, Taylor & Co.—This is an abridgement and revision of the Manual of Inorganic Chemistry, with which is incorporated, under carbon, the elements of organic chemistry in some 70 pages. It retains the excellencies of the Manual, by its dimensions, is better adapted to most of our colleges, academies, and schools, is much improved for the class-room by judicious paragraphing, and is unquestionably one of the best text-books in the language.

7. *The Popular Science Monthly*, conducted by E. L. YOUMANS. Each number 128 pp. 8vo. Published by D. Appleton & Co., New York.—The first number of this important monthly appeared in May. The two issued treat, as the title implies, of subjects that are now especially occupying the popular mind. The largest topic is man in his various relations, zoological, geological, social, political, educational, religious, etc.; and the widest range of opinion is presented on some of these subjects, in the different papers. Herbert Spencer commences in these numbers a series of able papers on Social Science or Sociology. Other articles treat of the eclipse of the sun; the sun's spots: Vesuvius; the superstitions of medicine; the artificial production of stupidity in schools; the physiological position of alcohol, and various miscellaneous topics of interest. The June No. has as a frontispiece an excellent portrait of Sir Charles Lyell.

OBITUARY.

DR. WILLIAM STIMPSON.—As these last pages are going to press, we learn that Dr. Stimpson died on the evening of the 26th of May. He had recently returned from a dredging expedition across the Gulf of Mexico, and had been very ill since his return. He has for many years been well known as one of the leading zoologists of this country, and has devoted himself chiefly to marine invertebrata. A more extended notice is deferred to the next number.

A Catalogue of the Birds of Kansas, by Frank H. Snow, Prof. Nat. Hist. and Meteorology in the University of Kansas, at Lawrence. Contributed to the Kansas Academy of Science. 8 pp. 8vo, Topeka, Kansas, 1872. This list contains the names of 239 species, with brief notes on many of them.

ERRATA.

Page 448, note, for p. 44, read p. 447.
Page 457, 14 lines from bottom, for basioccipital keel, read supraoccipital keel.

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